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A MONOGRAPH

OF THE

BRITISH
FOSSIL SPONGES.

VOL. I.

SPONGES OF PALÆOZOIC AND JURASSIC STRATA.

BY

GEORGE JENNINGS HINDE, PH.D., F.R.S.

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PART I.

(Pages 1—92. Plates I—VIII.)

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INTRODUCTION.

Though Fossil Sponges are mentioned in some of the earliest works in which fossils are treated of, and descriptions of them appear in nearly all subsequent works on palæontology, their true characters, until a comparatively recent date, were completely misunderstood, and their history was a mass of hopeless confusion. In the absence of any clear ideas as to the real nature of these organisms, the most heterogeneous materials were relegated to the group, and indeed it might be said to have been the practice—not altogether obsolete even now—to regard as a Sponge any fossil whose structure was too obscure to be satisfactorily placed elsewhere. One of the principal reasons for the chaos which existed was the erroneous idea, enunciated more particularly by D'Orbigny and Fromentel, that fossil Sponges belonged to an entirely extinct group, of a different nature to those now living, and consequently that no clue could be obtained to their original structures by a comparison with those of living forms.

Acting on this mistaken idea, those who studied the fossil forms did not attempt to carry out a systematic investigation of their skeletal structures, like that which had been so successfully applied to existing Sponges, but they were content to limit their investigations to the external form and the superficial canal structures, features possessed in common by many Sponges whose skeletal characters are essentially diverse. The classification thus based, was for the most part valueless and misleading. Here and there observers were not wanting who noticed the importance of the skeletal structures of these fossils, and amongst these Étallon deserves special mention; but no thorough attempt was made to apply the principle of the character of the skeleton, as the basis of classification, until that successfully carried out by Professor Zittel in 1877–78. Since the publication of Zittel's

'Studien ueber fossile Spongien' this principle has been recognised and acted on, and the status of fossil Sponges is no longer one of reproach and contempt. The impetus thus given to the study of these fossils is well shown by the various works on them which have since appeared in different countries, in which they are classified according to the minute characters of the spicular components of their skeletons, and the descriptions in the present work will be primarily founded on these features.

As preliminary to the description of the British forms I have thought it desirable to give a list of the principal works and papers treating of fossil Sponges generally, and short notices of their contents, in order to show, in chronological order, the views held respecting them at different times; and, further, to render the subject more readily intelligible to those who have not made a special study of this group of organisms, I have entered in some detail into the characters of the group generally, referring more particularly to the skeletal structures and to their condition of preservation, this last being a subject of special importance in connection with fossil Sponges, since the changes they have undergone have, in very many instances, completely masked their original features, and given rise to much of the misconception respecting their true characters.

BIBLIOGRAPHY.

1. 1699 Luidius [Lhwyd], E. Lithophylacii Britannici Ichnographia.

In this, one of the earliest works in which the fossil remains of this country are noticed, the Sponges are placed under the common term Alcyonium, and included in the second class of *Lapides corallini.* Most of the forms referred to and figured are Calcisponges from Faringdon in Berkshire. One of the commoner examples is stated to be mineral cartilage.

2. 1705 Plot, R. Natural History of Oxfordshire.

It is doubtful whether the forms represented as Fungites or Tuberoides are in reality Sponges or merely nodular flints from the Chalk.

3. 1708 Baer, J. J. Oryctographia Norica.

The fossil Sponges are referred to Alcyonia or Fungi. In the Supplement, published in 1730, very good figures are given of several species of Jurassic Sponges, which are placed in the family of the Fungitæ as marine fungi or Alcyonia. In a second Supplement, brought out in 1757 by the son of the original author, fresh examples of Jurassic lithistid and hexactinellid Sponges are figured and referred to the same groups. They are believed to be, together with other fossils, the relics of a common deluge.

4. 1708 Langius, C. N. Historia lapidum figuratorum Helvetiæ, ejusque viciniæ.

The Sponges figured and mentioned are from Jurassic strata, and they are regarded as either fossil plants or fruits. The former, styled fungi, are placed under four species, and one of tho latter is named *Alcyonia tuberosa.*

5. 1740 Scheuchzer, J. J. Sciagraphia lithologica curiosa.

Fossil Sponges are named Alcyonia and described as marine fungi.

6. 1742 Bourget, L., et Cartier, P. Traité des Pétrifications.

The Sponges figured are mostly the commoner forms of lithistids and hexactinellids from the Jurassic strata of Switzerland. They are stated to be marine plants and named 'Champignons de mer,' or 'Fruits de coralloide.'

7. 1751 Guettard, J. E. Mémoire sur quelques corps fossiles peu connus (*Mém. de l'Académie Royale des Sciences*).

Denies that the fig-shaped bodies (*Siphonia*), of which numerous specimens are figured, have any relation to figs or other fruits, but states that they are Sponges, differing in form only from ordinary ones. Vasiform and cup-shaped Sponges are regarded as possessing more affinity to Madrepores than to Sponges.

8. 1775 Knorr, G. W., et Walch, J. E. M. Recueil de Monumens des Catastrophes que la Globe de la Terre a esseuiées, contenant des pétrifications dessinées, gravées et enluminées d'après les originaux.

Many fossil Sponges are figured; some, apparently calcisponges, are regarded as Alcyonia, and their vents or oscules are stated to be the habitations of polypes. Siliceous hexactinellid and lithistid Sponges, from the Jurassic strata of Randen in Switzerland, are partly termed Fungites, and placed in the same group with genuine Corals, and partly placed under Escharites and Reteporites.

9. 1783 Guettard, J. E. Sur plusiers corps marins fossiles de la classe des Coraux (*Mém. de l'Acad. Roy. des Sciences*, vol. iv, Pls. 1—29.)

There are numerous figures of lithistid Sponges; some are styled Cariçoïdes and others Carico-Madreporites and Fungoïdes.

10. 1774–84 Schroeter, J. S. Vollstandige Einleitung in d. Kenntniss u. Geschichte d. Steine u. Versteinerungen.

Mentions a lithistid Sponge under the name of *Alcyonium ficus*, and regards it and other Alcyonia as Corals.

11. 1808 Parkinson, J. J. Organic Remains of a Former World.

In the second volume, the nature of fossil Sponges is discussed in detail, and the author records the results of a series of painstaking observations and experiments of grinding them down and treating the surfaces with acid. They are placed under Alcyonium or Spongia, and fully believed to have been produced by animals, though the author could form no idea of their nature. The author discovered cruciform spicules in the dermal layer of a hexactinellid Sponge, and noticed the quadrate arrangement of the mesh in the Jurassic genus *Pachyteichisma*. Reference is also made to the Ventriculites in flint. Very good figures are given of numerous species of Sponges from Jurassic, Greensand, and Chalk strata; the author, however, does not assign to them distinctive names, but places them all under the common term Alcyonites.

12. 1814 Webster, T. On some new varieties of fossil Alcyonia (*Transact. Geol. Soc.*, 1 S., vol. ii, p. 377, Pls. 27—30).

Describes and figures the lithistid Sponge now known as *Jerea Websteri*, under the name of *Tulip alcyonium.* Some specimens are erroneously stated to possess stems four to five feet in length.

13. 1815 Mantell, G. A. Description of a fossil Alcyonium from the Chalk Strata of Lewes (*Transact. Linn. Soc.*, vol. xi, p. 401, Pls. 27—30).

Examples of the Sponge, described later by the same author as *Ventriculites radiatus*, are referred to under the name of *Alcyonium chonoides*. These forms

are believed to have had powers of contraction and expansion, and the radiating ridges of the under surface of the Sponge are stated to be fasciculi of muscular fibres.

14. 1816 SMITH, W. Strata identified by Organised Fossils.

Figures are given of species of *Ventriculites* and *Cephalites* from the Upper Chalk under the name of flint Alcyonites. Specimens of *Doryderma*, *Siphonia*, and *Tremacystia* from the Upper Greensand are similarly placed under *Alcyonites*. These fossils are not described.

15. 1820 KÖNIG, C. Icones fossilium sectiles.

Four species of hexactinellid Sponges from Jurassic strata are placed in the genus *Spongus*, as Polypi, ordo incertus. The author remarks that these and similar fossils are usually regarded as Alcyonia, but that true Alcyonia are unknown in the fossil condition.

16. 1820 SCHLOTHEIM, E. F. v. Die Petrefaktenkunde.

In this work fossil Sponges are not distinguished from Corals. Some are named Fungiten and others Alcyonites, whilst under the term Spongiten are included true Corals.

17. 1820 SCHWEIGGER, A. F. Handbuch d. Naturges. d. skeletlosen ungegliederten Thiere.

Recent Sponges are regarded as Corals without polyps, and are placed under three leading groups or genera, *Achilleum*, *Manon* or *Tragos*, and *Scyphia*. These generic terms were subsequently very generally adopted for fossil Sponges.

18. 1821 LAMOUROUX, J. Exposition méthodique des Genres de l'ordre des Polypiers.

The fossil Sponges described and figured are classified in a peculiar manner. The genus *Eudea*, a calcisponge, is placed in the order Millepora; *Hallirhoa*, a lithistid, in the order Alcyonia, whilst the nearly allied genus *Jerea* is placed in the order Actinaires, together with *Chenendopora*, *Hippalimus*, and *Lymnorea*. These bodies are stated to have been soft in their living condition, and capable of expansion and contraction.

19. 1822 PARKINSON, J. An Introduction to the Study of Fossil Organic Remains.

Fossil Sponges are definitely recognised as of the same nature as recent forms, and their occurrence is noted in the Lower Greensand of Faringdon, the Upper Greensand of Wiltshire, and in the flints of the Upper Chalk. They are placed in the tribe Zoophytes. The genus *Siphonia* is defined, and its principal character is stated to be " a spongeous substance, pierced by a bundle

of tubes." Many different forms of Sponges are included in the genus, but the specimen first referred to it, and therefore the type of the genus, is now known as *Siphonia Kœnigi*, Mant. Another genus, *Mantellia*, is proposed to include *Alcyonium chonoides*, Mant., but the characters given are very indefinite, and the specimen figured as an example does not belong to the same genus as Mantell's species.

20. 1822 Mantell, G. A. The Fossils of the South Downs, &c.

Many of the commoner fossil Sponges from the Upper Chalk are described and figured. Some are referred to *Alcyonites*, others to *Spongus* and *Spongia*. The genus *Ventriculites* is constituted; the forms are believed to have been originally of a spongeous or gelatinous substance, possessing contractile properties. The genus *Choanites* is proposed, but the characters given are too indefinite to be of any value, and the three species placed under it belong to as many different genera.

21. 1829 Rose, C. B. On the Anatomy of the *Ventriculites* of Mantell (*Mag. Nat. Hist.*, vol. 2, p. 332).

The author agrees with Mantell that they are retractile, and they are stated to consist of an inner coat, with the openings of transverse tubes, a reticulated parenchyma, and an external coat, partly of a coriaceous and elastic integument. Each Ventriculite is regarded as a single gelatinous polype.

22. 1816-30 Dictionnaire des Sciences Naturelles.

The classification of Lamouroux is adopted generally for fossil Sponges. The genus *Receptaculites* is described as probably belonging to the Polypiers, and the doubtful genus *Verticillites* is also placed in the same group.

23. 1831 Benett, E. A Catalogue of the Organic Remains of the County of Wilts; Pls. 1—15.

Excellent figures are given of numerous forms of lithistid Sponges from the Upper Greensand and the Upper Chalk. The Sponges are not described, but they are included in the common term *Polypothecia*. Specimens of *Camerospongia* are placed under *Choanites*, Mant.

24. 1826-33 Goldfuss, A. Petrefacta Germaniæ, vol. i.

Fossil Sponges are regarded as the remains of Zoophytes, the plant-animals of the past. Numerous new species are described, and they are, for the most part, placed under the indefinite generic terms proposed by Schweigger for living keratose Sponges. The genus *Siphonia*, Park., is more strictly defined, and the new genera *Cnemidium*, *Myrmecium*, *Coscinopora*, and *Cœloptychium* are instituted, principally on their external characters. The spicular structure is only referred to as reticulate or lattice-shaped fibres or threads, which

are supposed to have been soft and gelatinous in the living condition. Most of the Sponges are from the Jurassic and Cretaceous strata. The figures are very faithful; in some instances the spicular structure has been represented, as well as the Sponge itself.

25. 1833 WOODWARD, S. An Outline of the Geology of Norfolk.

Under the heading of Polypi a list of seven species of Sponges is given, in which *Cœloptychium agaricoides*, Goldf., and *Ventriculites infundibuliformis*, n. sp., are included. These are figured but not described.

26. 1834 BLAINVILLE, H. M. DE. Manuel d'Actinologie.

Sponges are placed in the group Amorphozoaires; fossil Sponges are regarded as of the same nature as living ones, and, in some cases, both fossil and existing species are placed (though incorrectly) in the same genus. The author accepts Goldfuss's theory respecting the character of their fibres. For Sponges with skeletal spicules of carbonate of lime, the term Calcispongia is proposed. The figures given are mostly reproductions from the works of Lamouroux and Goldfuss.

27. 1835 PHILLIPS, JOHN. The Geology of Yorkshire, vol. i.

Names are given to fifteen of the commoner species of Sponges from the Upper Chalk of Flamborough, Yorkshire. They are included under the generic term *Spongia;* there are no descriptions, and the figures are of so rude a character that there is great difficulty in recognising the forms supposed to be represented.

28. 1836 SOWERBY, J. DE C. Descriptive Notes, &c. (*Trans. Geol. Soc.*, ser. 2, vol. iv).

A description is given of *Siphonia pyriformis* (now *S. tulipa*, Zitt.) from the Upper Greensand, Blackdown, and on Pl. XV A, excellent illustrations are furnished of various examples showing the canal-structures.

29. 1837 HISINGER, W. Lethæa suecica.

Two species of *Siphonia* (now *Astylospongia*) are mentioned, *S. præmorsa* and *S. stipitata.*

30. 1839 ROEMER, F. A. Die Versteinerungen des norddeutschen Oolithen-Gebirges. Nachtrag.

The fossil Sponges are mostly calcisponges; they are placed under *Tragos* and *Scyphia.*

31. 1839 LEE, J. E. Undescribed Zoophytes from the Yorkshire Chalk (*Mag. Nat. Hist.*, vol. iii, pp. 10—17, figs. 1—15).

The forms are lithistid Sponges, which are placed in the genera *Siphonia* and *Spongia;* only their superficial characters are referred to.

32. 1839 BRONN, H. G. Lethæa geognostica.

In this work the following genera of fossil Sponges from Oolitic and Cretaceous strata are stated to possess an internal fibrous reticulated structure, *Scyphia*, *Tragos*, *Mammillopora*, *Cnemidium*, *Myrmecium*, and *Hippalimus*. Some of these genera are supposed to include horny Sponges, both recent and fossil.

33. 1839 HAGENOW, F. v. Monographie der rügenschen Kreideversteinerungen (*Neues Jahrb.*, p. 260).

The Sponges are placed with Corals and Polyzoa as Polyparien. Species of *Achilleum*, *Manon*, *Scyphia*, and *Siphonia* are named, and references given.

34. 1839 MURCHISON, R. I. Silurian System.

Names and gives a figure of *Ischadites Kœnigii* (p. 697, Pl. xxvi, fig. 11). Its affinities are considered very doubtful.

35. 1840 ROEMER, F. A. Die Versteinerungen des norddeutschen Kreidegebirges.

Numerous species of Sponges, many of them new, are described. They are for the most part placed in the meaningless genera, *Spongia*, *Achilleum*, *Manon*, *Tragos*, *Cnemidium*, and *Scyphia*. The new genus *Pleurostoma* is constituted. The descriptions are very brief and indefinite, and regard chiefly external characters. The minute spicular structure of many hexactinellid Sponges is described as lattice-shaped fibre and distinctly figured, but these Sponges are included in the same genus with lithistid and calcisponges.

36. 1841 MÜNSTER, GRAF ZU. Beiträge zur Petrefacten-Kunde.

Numerous species of Calcisponges from the St.-Cassian beds are described and figured. They are regarded as polyps and placed in the genera *Achilleum*, *Scyphia*, &c.

37. 1842–44 KONINCK, L. DE. Description des Animaux fossiles dans le terrain carbonifère de Belgique.

Describes as a new genus of Corals, *Mortiera*; a biconcave siliceous fossil, composed of thin lamellæ. It is now regarded as a Sponge (P. 12, Pl. B, fig. 3).

38. 1842 BOWERBANK, J. S. On the Spongeous Origin of Moss-agates and other Siliceous Bodies (*Ann. and Mag. Nat. H.*, vol. x, pp. 9, 84, Pls. i—iii).

The fibrous appearances in sections of moss-agates are stated to be due to the presence of keratose Sponges, and the chert of the Greensand strata and the flints from the Chalk are believed to have been produced by the continued attraction and solidification by keratose Sponges of the silex in solution in the ocean.

39. 1842 Bowerbank, J. S. On the Siliceous Bodies of the Chalk, Greensands, and Oolites (*Trans. Geol. Soc.*, Lond., 2 S., vol. vi, pp. 181—194).

Regards the flints of the Chalk and the chert in the Greensand and Oolites as Sponges which have been filled in with silica, attracted by the animal matter of the Sponge, and not by the presence of the spicules.

40. 1843 Klipstein, E. Beiträge zur geologischen Kenntniss der oestlichen Alpen.

The Sponges are mostly calcisponges from the St. Cassian beds, which are placed in the same genera as those previously described by Count Münster. They are regarded as coral-polyps with a structure of reticulate fibres.

41. 1843 Geinitz, H. B. Die Versteinerungen von Kieslingswalda.

New species of hexactinellids, lithistids, and probably of calcisponges from the lower Pläner of Plauen are placed under *Cnemidium*, *Tragos*, and *Manon.*

42. 1843 Quenstedt, F. A. Das Floetzgebirge Württembergs.

The Sponges from the limestone strata of the Middle White Jura, which, for the most part, had been already figured by Goldfuss, are here described in greater detail. The lattice-like, "gitterformig," structure of many hexactinellids is recognised, but such forms are nevertheless included with lithistids and calcisponges in the undefined genus *Spongites*. Other lithistids are placed under *Cnemidium* and *Tragos.*

43. 1843 Portlock, J. E. Report on the Geology of Londonderry.

Various species of Cretaceous hexactinellid and lithistid Sponges are placed in the genera *Achilleum*, *Ventriculites*, *Scyphia*, *Coscinopora*, and *Siphonia*. A bundle of spicular rods forming the anchoring rope of a hexactinellid Sponge is described as a species of *Serpula.*

44. 1845 Reuss, A. E. Die Versteinerungen der böhmischen Kreideformation.

The Sponges are placed under Amorphozoa. The author states that the genera recognised by Goldfuss are without practical value, and yet he does not discard them. Good detailed descriptions and figures are given of the various species so far as their form and canal-structures are concerned, but no special importance is given to their spicular structures, which are described as a meshwork of reticulate fibres. The species are nearly entirely of lithistid and hexactinellid Sponges. The genus *Plocoscyphia* is defined.

45. 1846 D'Archiac. Description des Fossiles des environs de Bayonne (*Mém. de la Soc. Géol. de France*, S. 2, T. 2, p. 197, Pl. V, fig. 15 *a*; Pl. VIII, figs. 5—7).

Describes as a new species, *Guettardia Thiolati*, stated to be derived from Tertiary strata at Biarritz.

46. 1846 PICTET, F. E. Traité élémentaire de Paléontologie, Tome iv.

Fossil Sponges are placed in the group of Amorphozoaires of Blainville, but it is considered doubtful whether they possessed true polyps, like Alcyonia, or were without them. They are for the most part regarded as true horny Sponges, but it is supposed that some genera, such as *Siphonia*, *Jerea*, *Myrmecium*, and others, may have been provided with true polyps, and therefore belonged to Corals.

47. 1840–47. MICHELIN, H. Iconographie Zoophytologique.

Numerous species of Sponges from the Cretaceous and Jurassic strata of France are described and figured. The descriptions are very brief and refer merely to the superficial characters. Nothing definite is stated respecting the nature of fossil Sponges, but they are apparently regarded as of the same character as recent horny Sponges, which have become siliceous or calcareous by fossilisation. They are mostly placed under the genera *Spongia*, *Jerea*, *Siphonia*, &c., of previous authors. Two new genera, *Guettardia* and *Turonia*, are proposed.

48. 1847 OSWALD, F. Ueber die Petrefacten von Sadewitz (*Uebersicht Arbeit. und Verand. Schles. Gesell.*, p. 56).

Defines the Silurian genus *Aulocopium*, and places under it fourteen species, the names only of which are given. Species of *Scyphia* and *Tragos* are similarly named, but not described.

49. 1847–48 SMITH, J. TOULMIN. The Ventriculidæ of the Chalk (*Ann. and Mag. Nat. Hist.*, vol. xx, pp. 73, 176, Pls. VII, VIII, and 2nd ser., vol. i, pp. 36, 203, 279, 352, Pls. XIII—XVI).

The minute structure, though not the true nature of fossil hexactinellid Sponges, is for the first time fully described. They are shown to consist of thin, variously folded membranes, formed of a rectangular tissue of anastomosing fibres, which at the points of intersection possessed hollow or octahedral nodes. Several different kinds of tissue, that of the substance of the body, a finer subdermal membrane, an exterior membrane, and that of the root-fibres are described, the nodes of this latter not being hollow. The membranes are not believed to have been originally of a mineral nature, but are regarded as replacements by silica, iron, or lime of the original animal structures. The fossils are regarded by the author not as Sponges, but as the skeletons of polyzoa or ascidian polypes, in opposition to the opinion of Prof. John Morris that they were Amorphozoa or Sponges. They are placed in the genera *Ventriculites*, *Cephalites*, and *Brachiospongia*. This last is obsolete, as it is only a synonym of the previously constituted *Plocoscyphia*, Reuss, and *Guettardia*, Mich.

50. 1848 Roemer, Ferd. Ueber eine neue Art der Gattung *Blumenbachium*, Koenig, und mehre unzweifelhafte Spongien in Obersilurischen Kalkschichten der Grafschaft Decatur im Staate Illinois in Nord America (*Leonhard u. Bronn's Neues Jahrbuch*, pp. 680—686, Pl. IX).

Recognises the similarity in the nature of the spicules of *Blumenbachium meniscus* (now *Astræospongia*) to that of living siliceous Sponges. Undoubted Sponges from the Silurian strata (Niagara group) of North America are compared with Cretaceous Sponges and placed in the genus *Siphonia*. Subsequently the author placed these forms in a distinct genus, *Astylospongia*.

51. 1848 M'Coy, F. On some new Mesozoic Radiata (*Ann. and Mag. Nat. Hist.* 2nd ser., vol. ii, p. 397).

Describes the superficial characters of four species of Cretaceous and Oolitic Sponges. No figures are given.

52. 1848 Mantell, G. A. Wonders of Geology, 6th edition.

In this edition various species of Sponges from the Chalk and Greensand are figured, and referred to in general terms as Sponges and Zoophytes. *Ventriculites* is still stated to have been contractile.

53. 1848 Charlesworth, E. On the Mineral Condition and General Affinities of the Zoophytes of the Chalk at Flamborough and Bridlington (*Proc. Yorks. Phil. Soc.*, vol. i, p. 73).

These Sponges are apparently regarded as having been originally of a horny character, and attention is called to the fact that their tissues are now silicified. The different species named by Phillips are believed to be merely modifications of a single form, for which the author proposes the name *Rhizospongia polymorpha*.

54. 1849–52 D'Orbigny, A. Prodrome de Paléontologie.

The Sponges are placed under Amorphozoa, numerous genera and species are introduced, but the characters given are so brief and indefinite that, in the absence of figures, it is impracticable to recognise them satisfactorily.

55. 1850 King, W. Monograph of the Permian Fossils (*Pal. Soc.*, pp. 11—14, Pl. 2).

Refers some doubtful organisms to the genera *Scyphia*, *Mammillopora*, *Tragos*, and *Bothroconis*, n. g. Only their external characters are described.

56. 1850 Dixon, F. Geology and Fossils of Sussex.

Some specimens and polished surfaces of *Siphonia* in flint are figured, but nothing is stated of them beyond the fact that they are Sponges.

57. 1851 Morris, J. Palæontological Notes (*Ann. and Mag. Nat. Hist.*, 2nd ser., vol. 8, p. 88).

Refers to the cavities, now infilled with silica, in Cretaceous *Inocerami* and *Belemnitella*, and regards them as produced by the borings of Sponges, like *Cliona*.

58. 1852 Wetherell, N. T. Note on a New Species of *Clionites* (*Ann. and Mag. Nat. Hist.*, 2nd ser., vol. x, p. 354, Pl. 5, figs. 1, 2).

Describes small oval infillings in the shell of *Inoceramus*, which, however, do not appear to have any relation to boring Sponges.

59. 1852 Giebel, E. G. Deutschlands Petrefacten.

The Sponges are placed under Amorphozoa. References are given to the description, geological position, and place of occurrence of 148 species from the strata of Germany.

60. 1852 Quenstedt, F. A. Handbuch der Petrefaktenkunde.

References are made to most of the Jurassic species of Sponges described by Goldfuss, as well as to *Ventriculites* and *Siphonia*. The external characters and canal structures are described in detail. The similarity of the skeleton of some of the Jurassic Sponges to that of *Ventriculites* is recognised, as well as the resemblance of detached fossil Sponge spicules to those of existing Sponges. Fossil Sponges generally are stated to consist of interwoven fibres, between which calcareous or siliceous spicules occur, but the spicular nature of the fibre itself is not noticed.

61. 1852 D'Orbigny, A. Cours élémentaire de Paléontologie.

Sponges are placed in the group Amorphozoaires of Blainville, their skeletons are stated to be either "corné" or "testacé," fibreux" or "poreux." The author denies that fossil Sponges ever possessed a horny skeleton, like many living forms, but states that they were always calcareous and stony. Sponges generally are placed in two groups; those with horny skeletons, of which the only fossil representatives are species of *Cliona*, and those with stony (testacé) skeletons, which are exclusively fossil, and no longer exist. For these latter the following families are proposed:—(1) *Ocellaridæ;* (2) *Siphonidæ;* (3) *Lymnoreidæ;* (4) *Sparsispongidæ*, and (5) *Amorphospongidæ*. The skeletal characters are referred to in a general manner as filamentous tissues, and no distinction is made between siliceous sponges and calcisponges. Numerous new genera are introduced, but their characters are too indefinite to possess any value.

62. 1854 Ehrenberg, C. G. Mikrogeologie.

Numerous detached Sponge spicules from fossil and sub-fossil deposits are figured, but no reference to their characters is given; the general term *Spongolithis* is applied to them all, and a distinctive name is given to every variety of form, though evidently many of these belong to the same species.

63. 1854 Sharpe, D. On the Age of the Fossiliferous Sands and Gravels of Faringdon (*Quart. Journ. Geol. Soc.*, vol. x, p. 176, Pl. V).

Sixteen species of fossil Sponges are enumerated; some new forms are placed in the genus *Manon*, and others are erroneously referred to species described by Lamouroux and Goldfuss from the Upper Greensand. No reference is made to the fact that the Faringdon examples are exclusively calcisponges.

64. 1854 Mantell, G. A. Medals of Creation, 2nd edition.

It is stated, in opposition to D'Orbigny, that keratose Sponges are abundant as fossils. Most of the Sponges from the Chalk and Greensand are apparently referred to this group, and included under *Spongites. Siphonia* and *Choanites* are regarded as distinct genera; the latter is supposed to have been originally of a soft gelatinous substance strengthened by spicula, but the spicula figured do not belong to this genus.

65. 1854 Morris, J. A Catalogue of British Fossils, 2nd edition.

Under the heading *Amorphozoa*, 148 species of Sponges are enumerated, which are placed in thirty-one genera. About nineteen of these genera are now regarded as obsolete.

66. 1855 M'Coy, F. Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge.

In a footnote it is stated that no Amorphozoa are described in the work, but two species of *Steganodictyum* (now known to be the shields of fishes) are figured as Sponges. *Pyritonema fasciculus*, the root-appendage of a hexactinellid Sponge, is compared with *Hyalonema*, then regarded as a Zoophyte; and *Tetragonis Danbyi* (now *Dictyophyton*) is placed in the order Cystidea.

67. 1858 Eley, H. Geology in the Garden, or the Fossils in the Flint Pebbles.

Describes and figures various forms of detached monactinellid, tetractinellid and hexactinellid spicules from the interior of flints, and concludes that Sponges were most prevalent in the Chalk Seas (pp. 177—184, Pl. I).

68. 1858 Quenstedt, F. A. Der Jura.

Specific descriptions, limited, however, to superficial characters, are given of most of the Jurassic Sponges, and the previous classification of the author is followed.

69. 1859 Fromentel, E. de. Introduction à l'Étude des Éponges Fossiles (*Mém. de la Soc. Linnéenne de Norm.*, T. xi, pp. 1—50, Pls. I—IV).

The group of Sponges is placed under two main divisions, that of Spongiaires or living Sponges, with a skeleton of spicules, or of spicules and horny fibres; and that of Spongitaires or fossil Sponges, in which the skeleton consists of a stony meshwork, which may or may not include spicules. The classification proposed is based mainly on the nature of the canal-system, and an altogether subordinate value is placed on the characters of the skeleton. Fossil Sponges are divided into the following suborders, *Spongitaria tubulosa*, *S. osculata*, and *S. porosa*. The classification is not a natural one since it includes various forms of siliceous sponges and calcisponges in the same family.

70. 1859 Thurmann, J., et Etallon, A. Lethæa Bruntrutana, ou Études Paléontologiques et Stratigraphiques sur le Jura Bernois, et en particulier les environs de Porrentruy (*Nouv. Mém. de la. Soc. helvet. des Sciences natur.*).

Numerous species of Sponges, for the most part calcisponges apparently, are described, but only their superficial characters are referred to.

71. 1860 Fromentel, E. de. Catalogue raisonné des Spongitaires de l'Étage Néocomien (*Bullet. de la Soc. des Sciences de l'Yonne*, 4e Série, pp. 1—19, Pls. I—IV).

Three new genera and several new species are introduced; the same classification is adopted as in the author's 'Introduction,' and it is stated to be based on positive and natural characters.

72. 1860 Etallon, A. Sur la Classification des Spongiaires du Haut Jura et leur distribution dans les Étages (*Actes de la Société Jurassienne d'Emulation pendant* 1858, pp. 129—160, Pl. I).

Describes very clearly the true character of the skeleton of hexactinellid Sponges as consisting of spicules amalgamated at their points so as to form a regular cubic network. These Sponges are placed in the family of the Dictyonocœlides. In the family of the Petrospongides the skeleton is supposed to be without spicules, and this family apparently includes calcisponges. A third family is named Clionides. Lithistid Sponges are not particularly noticed, and they are not comprised in the definition of the proposed groups. The author was one of the first to recognise the value of the skeletal structures of fossil Sponges as a basis of classification.

73. 1860 Capellini und Pagenstecher. Mikroscopische Untersuchungen über den innern Bau einiger fossilen Schwämme (*Zeitsch. f. wiss. Zoologie*, Bd. x, p. 364, Pl. xxx).

The spicular structure of several species of hexactinellid Sponges from the

Jurassic strata of St. Claude is described and the presence of canals in the axes of the spicules is noted, and their resemblance to the *Ventriculites* of Toulmin Smith is pointed out. This siliceous skeleton is stated to correspond to the horny skeleton of living Sponges, and cannot be compared to the spicules of existing forms.

74. 1860 D'Eichwald, E. Lethæa Rossica, vol. i, p. 325.

Describes species of *Scyphia*, *Siphonia*, *Thoosa*, and of several other genera, but judging from the characters and the figures it is very doubtful if any of the forms are genuine Sponges.

75. 1860 Roemer, Ferd. Die Silurische Fauna des westlichen Tennessee.

Describes in greater detail than hitherto various species of *Astylospongia*, also proposes the genus *Palæomanon* for cup-shaped Sponges with the same spicular structure as *Astylospongia*. *Astræospongia* is regarded as a Calci-sponge.

76. 1861 Owen, R. Palæontology, pp. 5—8.

Sponges are placed under the class Amorphozoa and brief reference is made to their distribution in British strata. Calcareous Sponges are stated to abound in the Oolitic and Cretaceous strata, attaining their maximum development in the Chalk. No reference is made to the structure of *Ventriculites* or of *Guettardia*. *Siphonia* and the allied genera, grouped together as Petrospongiadæ, are stated to possess a stony reticulated frame without spicules and to have passed away with the Secondary epoch.

77. 1861 Geinitz, H. B. Die animalischen Uebereste der Dyas, pp. 123, 124, Pl. XX.

Refers to two species of *Spongia* some fossils of doubtful character, and copies the descriptions given by King of the reputed Sponges from the English Permian.

78. 1861 Courtiller, A. Éponges fossiles des Sables du Terrain Crétacé supérieur des environs de Saumur (*Ann. de la Soc. Linn. de Maine-et-Loire*, 4ᵉ vol., pp. 1—26, Pls. I—XL).

Numerous species are described and referred to various genera. Only their superficial characters are noticed, and the species have thus little, if any, value.

79. 1861 Roemer, Ferd. Die fossile Fauna der silurischen Diluvial-Geschiebe von Sadewitz.

Several new species of *Astylospongia* are described; the spicular structure of the genus is stated to consist of very regular six-rayed, star-shaped bodies, so united together that the rays of one star are intimately united with those

of the proximately adjoining stars. The genus *Aulocopium*, Oswald, is further defined, and several new species included therein; its intimate structure is stated to be a fibrous tissue. A fresh species of *Astræospongia* is also described.

80. 1861 SALTER, J. W. Mem. Geol. Surv. of Great Britain; 32, Scotland, p. 135, Pl. II, figs. 3, 3 *a*.

Describes and figures *Amphispongia oblonga* from the Silurian of the Pentland Hills, as a calcisponge allied to *Grantia*.

81. 1861 LORIOL, P. DE. Description des animaux invertébrés contenus dans l'étage Néocomien moyen du Mont Salève.

Numerous species of Sponges are described and figured, only their external characters are referred to, and the classification of Fromentel is adopted. The forms are evidently calcisponges for the most part, with one or two species of hexactinellids.

82. 1862[1] GRIFFITH and M'COY. A Synopsis of the Silurian Fossils of Ireland.

A single Sponge is described under the name of *Acanthospongia Siluriensis*. The spicules are stated to be of the shape of the letter X, and to possess six rays. No figure is given.

83. 1863 HALL, J. Observations upon the genera *Uphantænia* and *Dictyophyton* (*Sixteenth Annual Report of the New York State Museum of Natural History*, p. 84, Pls. iii—v, v *a*).

These fossils, now regarded as Sponges, are described as Algæ of a peculiar form and mode of growth. Numerous species are figured and referred to.

84. 1863 HALL, J. Note on the Occurrence of *Astylospongia* in the Lower Helderberg Rocks (*Sixteenth Annual Report of the New York State Cabinet*, p. 69).

A globose body is described under the name of *Astylospongia inornata*, but there is no account of its internal structure, and it is probably wrongly referred to this genus.

85. 1864 ROEMER, F. A. Die Spongitarien des norddeutschen Kreidegebirges (*Palæontographica*, Bd. xiii, pp. 1—63, Pls. I—XIX).

In this important work the artificial systems of classification of D'Orbigny and Fromentel are adopted, with the result of uniting into the same group Sponges whose structures are very distinct. The tissue of fossil Sponges is regarded as either lattice-like or vermiculate. The former is stated to consist of very thin, smooth, siliceous rods, which grow together so as to make a lattice-like web, with octahedral nodes. The vermiculate fibres may be either siliceous or calcareous; in the former case the structure resembles the lattice-

[1] The date on the title-page of this book is 1846, but it was not published and sold until 1862.

like tissue, and it is likewise composed of spicules. Thus, whilst hexactinellid Sponges are, for the most part, by themselves, lithistid and calcisponges are united into one group. Numerous species are described and figured, but the characters given are very brief and inadequate for satisfactory recognition.

86. 1864 SALTER, J. W. On some new Fossils from the Lingula Flags of Wales (*Quart. Jour. Geol. Soc.*, vol. xx, p. 238, Pl. XIII).

Describes, as a new genus and species, *Protospongia fenestrata*, from Menevian strata. It is stated to possess a reticulate skeleton of large cruciform spicula.

87. 1864 FROMENTEL, E. DE. Polypiers Coralliens des Environs de Gray (*Mém. de la Soc. Linn. de Norm.*, vol. xiii).

Various species of calcisponges are figured on Pl. xv.

88. 1865 BILLINGS, E. Palæozoic Fossils, vol. i (*Geological Survey of Canada*).

An elaborate description is given of the characters of the genus *Receptaculites*, which is regarded as probably a Sponge. The spicules are compared with the birotulate forms in the gemmules of the freshwater *Spongilla*. *Archæocyathus*, *Calathium*, and *Eospongia* are also described provisionally as Sponges.

89. 1865 DE FERRY. Note sur les Crustacés et les Spongitaires de la base de l'étage Bathonien des environs de Macon (*Bull. de la Soc. Linn. de Normandie* (Caen), vol. ix, pp. 365—375).

Silicified bodies of irregular form are referred to the genera *Siphonocœlia* and *Discœlia*. Their affinities appear to be very doubtful.

90. 1865 LAUBE, G. C. Die Fauna der Schichten von St. Cassian (*Denkschrift d. k. Akad. d. Wiss. Wien*, Bd. 24.

Numerous species of calcisponges are described, but no information is given respecting their skeletal structures.

91. 1865 TATE, R. On the Correlation of the Cretaceous Formations of the North-East of Ireland (*Quart. Journ. Geol. Soc.*, vol. xxi, p. 43, Pl. V).

Two new genera of hexactinellid Sponges are proposed, *Etheridgia* and *Cœloscyphia*; and two species of *Cœloptychium* are regarded as new forms.

92. 1866 MACKIE, S. J. An Illustrated Catalogue of British Fossil Sponges, Part II, pp. 1—32, Pls. I—IV.

Only the second part of this extraordinary work appeared. It consists of numerous extracts from the writings of Mantell, Toulmin Smith, and other authors on fossil Sponges, mingled with desultory remarks of the author himself. None of the figures on the four plates appears to be original.

93. 1866 Suess, E. On the existence of *Hyalonema* in a Fossil State (*Ann. and Mag. Nat. Hist.*, 3 S., vol. 18, p. 404).

States that the *Serpula parallela* of the Yorkshire Mountain-Limestone is a true glass-rope, and that it should be named *Hyalonema parallelum.*

94. 1867 Marsh, O. C. Notice of a New Genus of Fossil Sponges from the Lower Silurian (*Amer. Journ. Sci.*, S. 2, vol. 44, p. 88).

Describes the genus *Brachiospongia*, but its minute structure is not stated.

95. 1867 Reuss, A. E. Die Bryozoen, Anthozoen, und Spongarien des Braunen Jura von Balin bei Krakau (*Denks. d. k. Akad. d. Wiss. Wien*, Bd. 27).

Five species, apparently all calcisponges, are recorded, two of them, *Jerea biceps* and *Siphonocœlia gregaria* as new forms.

96. 1867 Rosen, Baron von. Ueber die Natur der Stromatoporen, und über die Erhaltung der Hornfaser der Spongien im fossilen Zustande.

This work more particularly treats of forms of *Stromatopora*, which are regarded as fossilized horny Sponges. These bodies are compared with genuine hexactinellid and lithistid Sponges from the Chalk of Saratow, which are believed to have had originally skeletons of a horny nature. The silicified Sponges are stated to be produced by the change of horny fibre into silica.

97. 1868 Fischer, M. P. Recherches sur les Éponges perforantes fossiles (*Nouv. Archiv. du Mus. d'Histoire Naturelle*, pp. 117—172, Pls. XXIV—XXX).

Sketches the history of these bodies, and describes and figures the known forms. States that *Entobia antiqua*, Portlock, is most probably a Bryozoan, and doubts that *Vioa prisca*, M'Coy, is due to a boring Sponge.

98. 1868 Loriol, P. de. Monographie des Couches de l'Étage Valangien des carrières d'Arzier (*Matériaux pour la paléontologie Suisse*, par Pictet).

The forms described, judging from the figures, are all calcisponges. Only their superficial characters are referred to, and they are ranged according to the classification of Fromentel.

99. 1868 Kostytschef, A., und Marggraf, O. Ueber die Chemische Zusammensetzung der in dem Apatitsandstein der russischen Kreideformation vorkommenden versteinerten Schwämme (*Bull. de l'Acad. de St.-Pétersb.*, vol. xiii, pp. 19, 20, 1869).

No reference is given to the kinds of Sponges which were analysed; the specimens consisted principally of phosphate of lime, of a similar composition to the fossilised wood and bones in the same deposit.

100. 1868 Bigsby, J. J. Thesaurus Siluricus.

Under Amorphozoa a list of 119 species is given, but about 70 of these may be definitely excluded from Sponges, and many others are undetermined or doubtful forms.

101. 1868 Lankester, E. Ray. On the Discovery of the Remains of Cephalaspidian Fishes in Devonshire and Cornwall; and on the Identity of *Steganodictyum*, M'Coy, with Genera of those Fishes (*Quart. Journ. Geol. Soc.*, vol. 24, p. 546).

Records that Mr. Salter determined that M'Coy's supposed Sponges, placed under *Steganodictyum*, are actually the cephalic plates of Pteraspidian fishes. Confirms this determination, and places the *Steganodictyum cornubicum*, M'Coy, under *Scaphaspis*, and *S. Carteri*, M'Coy, as allied to *Cephalaspis*.

102. 1868 Meek and Worthen. Palæontology of Illinois, vol. 3.

Species of *Receptaculites* and *Astræospongia* are described and figured.

103. 1869 Trautschold, H. Palaeontologischer Nachtrag (*Bull. de la Soc. Imp. des Naturalistes de Moscou*, p. 230, Pl. i).

Describes under the name of *Siderospongia sirenis* a platter-shaped body whose surface is covered with star-like canals. The nature of the organism is very doubtful.

104. 1869 Bowerbank, J. S. Monograph of the Siliceo-fibrous Sponges (*Proc. Zool. Soc.*).

Describes, amongst others, *Purisiphonia* as a new genus intermediate between *Dactylocalyx* and *Farrea* (p. 342). The only species, *P. Clarkei*, is probably from the Cretaceous strata of Queensland.

105. 1870 Roemer, Ferd. Geologie von Oberschlesien.

Numerous siliceous Sponges are referred to and figured; for the most part they belong to species already known.

106. 1870 Parfitt, E. Fossil Sponge Spicules in the Greensand of Haldon and Blackdown (*Transact. Devon. Assoc.*, vol. iv, pp. 138—144, 1 Pl.).

Detached spicules, resulting from the disintegration of tetractinellid and lithistid Sponges, are described and figured, and they are compared with the spicules of existing Sponges.

107. 1870 Cohn, F. Ueber das Vorkommen von Kieselschwammnadeln in einem dichten grauen Kalkstein (*Jahresb. Schlesch. Gesell.*, vol. xlviii, pp. 63, 64).

Records the occurrence of hexactinellid and lithistid spicules from a well-boring at Inowraclaw. The rock is believed to be of Cretaceous age.

108. 1871 GEINITZ, H. B. Die Seeschwämme des unteren Quaders. Die Seeschwämme des mittleren und oberen Quaders (*Palæontographica* Bd. xx, 1 Th., pp. 1—41, Pls. 1—10).

The identity of the minute structure of fossil Sponges with lattice-shaped mesh (Gitterschwämme, A. Roemer) and recent hexactinellids is recognised, and the fossil forms with this structure are placed in the same group with the recent. Fossil Sponges with the so-called vermiculate mesh are regarded as probably of the same nature as recent lithistid Sponges, and placed in the same group. The doubtful *Spongites* is placed under the *Halisarcinæ*. The classification adopted by this author marks a great step in advance. A mistake was made, however, in placing all Sponges with vermiculate fibres under the Lithistidæ, since many of them are calcisponges.

109. 1871 HICKS, H. Descriptions of New Species of Fossils from the Longmynd Rocks of St. David's (*Quart. Journ. Geol. Soc.*, vol. 27, p. 401, Pl. XVI, figs. 14—20).

Describes some doubtful lines on rock surfaces as *Protospongia* (?) *major* and *P.* (?) *flabella*.

110. 1871 PHILLIPS, J. Geology of Oxford and of the valley of the Thames.

Gives a list of the Amorphozoa of the Cretaceous system, and figures some of the commoner Sponges from the Lower Greensand of Faringdon.

111. 1871 CARTER, H. J. On Fossil Sponge Spicules of the Greensand compared with those of existing species (*Ann. and Mag. Nat. Hist.*, 4 S., vol. vii, pp. 112—141, Pls. VII—X).

Very numerous forms of detached spicules from the Upper Greensand of Blackdown and Haldon are shown to correspond very closely with the spicules of recent tetractinellid, lithistid, and hexactinellid Sponges.

112. 1871 SIMONOWITSCH, S. Beiträge zur Kenntniss der Bryozoen des Essener Grünsandes (*Verh. d. nat. Ver. Jahrg.*, xxviii, 3 Folge, Bd. viii).

Places as Bryozoa, *Thalamopora cribrosa,* Goldf., sp., and *T. michelinii*, n. (pp. 27—34, Pl. 1, I, 2), now shown to be calcisponges and included in *Tremacystia*, Hinde.

113. 1872 HAECKEL, E. Die Kalkschwämme.

The author denies the existence of entire fossil calcisponges and states that the forms generally known as such have no relation to the group. Further, states that the delicate character of recent calcisponges renders it impossible that similar forms can have been preserved in the fossil state, though it is not improbable that their detached spicules may yet be recognised.

114. 1872 Holl, H. B. Notes on Fossil Sponges (*Geol. Mag.*, vol. ix, pp. 309—315, 343—352).

Refers to the general characters of fossil Sponges, and points out the artificial nature of the classification of D'Orbigny and Fromentel. The following conclusions are given: (1) That the present state of fossil Sponges affords no certain indication of their condition during life, and (2) that in the differentiation of genera and species the same principles must be kept in view in fossil as in recent Sponges.

115. 1872 Dewalque, G. Un Spongiaire nouveau du système Eifelien (*Bull. Acad. Roy. de Belgique*, T. 34, pp. 23—26, Pl. 1).

Describes and figures a new species of *Astræospongia*.

116. 1872 Pomel, A. Paléontologie de la province d'Oran, 5 Fasci. (*Spongiaires*, pp. 1—256, 36 pls.).

The untenability of the theory of D'Orbigny and Fromentel that fossil Sponges are altogether distinct from recent forms is fully recognised. Pomel divides the class Spongiaires into two primary groups: (1) *Camptospongiaires*, in which the spicules when they exist are isolated and not organically attached together, and (2) *Petrospongiaires*, in which the skeleton is a continuous tissue of stony consistency. This latter group is again divided into *Dictyoscléroses*, which appears to be equivalent to hexactinellids, and *Psammoscléroses*, forms with skeletons of a granular or vermiform texture. In this latter order the author distinguishes two families, one with a calcareous and the other with a siliceous skeleton. As regards the skeleton of the *Dictyoscléroses*, or hexactinellid Sponges, Pomel maintains the same opinion as Roemer that the spicular tissue has in all cases originally been siliceous and that in the instances in which it is now calcareous the change has been produced by molecular displacement. Pomel thus appears to have been the first to recognise the substitution of calcite in the place of the original silica in the skeleton of fossil Sponges. The smaller subdivisions of Pomel are based upon the position and character of the so-called 'Proctides,' and most of the genera of previous authors are split up on very insufficient grounds. Numerous genera and species, apparently both of hexactinellid and lithistid Sponges, are described and figured, but their spicular characters are not referred to.

117. 1872 Murchison, R. I. Siluria, 5th ed.

In the table drawn up by Mr. Etheridge showing the vertical range of the Silurian Fossils of Britain, there are enumerated (p. 509) seventeen species of Amorphozoa, but ten of these are either doubtful forms or belong to other groups.

118. 1872 SCHLÜTER, C. A. Ueber die Spongitarien-Baenke der oberen Quadraten und unteren Mukronaten-Schichten des Münsterlandes (*Sitzungsb. d. Niederrhein. Gesells.*, pp. 1—38, Pl. 1).

Describes in detail the characters and stratigraphical distribution of the various Sponges in these beds, and constitutes two new genera of hexactinellid Sponges, *Lepidospongia* and *Becksia*.

119. 1873 SALTER, J. W. Catalogue of Cambrian and Silurian Fossils in Geol. Museum, Cambridge.

The forms referred to Sponges are placed under Amorphozoa. It is stated "that *Stromatopora, Coscinopora, Cnemidium, Verticillopora, Stellispongia, &c.*, are examples of very solid calcareous Sponges. *Ischadites*, *Sphærospongia*, *Amphispongia*, and other Silurian forms, are supposed to be distantly allied to the living *Grantia*." *Ischadites Kœnigii* is figured erroneously with stem and roots.

120. 1873 CARTER, H. J. On the Hexactinellidæ and Lithistidæ (*Ann. and Mag. Nat. Hist.*, vol. xii, p. 349, 437, Pls. xiii, xvii).

Refers in detail to the spicular structure of these groups as shown in existing species, and comparisons are made in one or two cases with fossil forms as well.

121. 1873 FISHER, O. On the Phosphatic Nodules of the Cretaceous Rocks of Cambridgeshire.

Refers to their constitution, and regards many of them as having originally been Sponges.

122. 1873 SOLLAS, W. J. On the Ventriculitæ of the Cambridge Upper Greensand (*Quart. Journ. Geol. Soc.*, vol. xxix, pp. 63—70, Pl. VI).

Describes the minute structure of the Ventriculite skeleton, which is stated to consist of the "regular anastomosis of a number of hexaradiate elements, each of which consists of six radial fibres, apparently tubular, diverging from a common centre, at right angles to each other." The constitution of these fibres is not stated, but the author mentions that he failed to find spicules, either in silicified or phosphatised Ventriculites. The silicified Ventriculites are regarded as instances of the silicification of highly decomposable animal matter, and the phosphatic Ventriculites 'are striking examples of the phosphatisation of soft-bodied animals.' The presence of siliceous *Xanthidia* and *Polycystina* in the Coprolites is adduced as 'an argument against regarding the Ventriculites as having originally had a siliceous skeleton which had subsequently been replaced by phosphate of lime.'"

123. 1874 Rutot, A. Note sur la découverte de deux Spongiaires de l'Étage Bruxellien des environs de Bruxelles (*Ann. de la Société Malacologique de Belgique*, Tome ix, pp. 1—14, Pl. 3).

Numerous siliceous accretions occur in these Tertiary beds, which are largely composed of the detached spicules of siliceous tetractinellid Sponges. These accretions are erroneously regarded as definite Sponges, and on them two species are based, *Stelletta discoidea* and *Dysidea tubulata*.

124. 1874 Wyville-Thomson, C. The Depths of the Sea.

The essential similarity in the minute skeletal structures of recent hexactinellid Sponges and of the *Ventriculites* of Toulmin Smith, is pointed out. An erroneous comparison is made between the general structure of *Cœlosphæra tubifex*, a recent monactinellid Sponge, and *Choanites*, a fossil lithistid, the body-canals of this latter form being mistaken for tube-like processes, present in the existing Sponge.

125. 1874 Davey, E. C. The Sponge-Gravel Beds at Coxwell near Faringdon.

A general description is given of the deposit, and reference made to the Sponges with which it is filled; they are placed in the obsolete genera *Manon*, *Tragos*, &c.

126. 1874 Meyn, L. Silurische Schwämme und deren eigenthümliche Verbreitung, ein Beitrag zur Kunde der Geschiebe (*Zeits. d. deutsch. geol. Gesell.*, vol. xxvi, pp. 41—58).

Treats of the state of preservation and mineral condition of the fossil Sponges in the Drift deposits of the Island of Sylt.

127. 1875 Gümbel, C. W. Beiträge zur Kenntniss der Organisation und systematischen Stellung von Receptaculites (*Abh. der k. bayer. Akad. der Wiss.*, II Cl., Bd. xii, 1 Ab., pp. 169—215, Pl. A).

A minute detailed description of the characters of the genus is given, its thick inner and outer walls are stated to consist of individual plates held in position by intervening pillars, and a branching canal-system is also present. The genus is included in the Foraminifera in close relationship to *Dactylopora*. The genus *Ischadites* is regarded as similar generically to *Receptaculites*, and *Protospongia* is also a related form.

128. 1874–75 Barrois, Ch. Sur la Philogénie des Éponges (*Ann. Soc. Géol. Nord*, pp. 71—73).

Refers to the presence of lithistid spicules in Devonian Sponges, and the abundant development of the hexactinellidæ in the Chalk, and of the Corticatæ

in Tertiary strata. States that Haeckel is wrong in denying the existence of calcisponges in the fossil state. Regards *Astræospongium* as a calcisponge.

129. 1875 Wright, Joseph. A List of the Cretaceous Microzoa of the North of Ireland (*Belfast Nat. Hist. Field Club Report* for year 1873–4, n. s., vol. i, pp. 72—80, Pls. II, III).

Amongst these are numerous detached siliceous spicules, obtained from the interior of flints from the Upper Chalk, which were compared by Dr. Bowerbank to the spicules of *Tethea*, *Geodia*, *Dactylocalyx*, and other siliceo-fibrous Sponges.

130. 1875 Pillet, M. L., et Fromentel, M. E. Description Géologique et Paléontologique de la Colline de Lémenc sur Chambéry.

Several species, mostly calcisponges, are described and figured, but no reference is made to their minute structures.

131. 1875 Billings, E. On some new or little-known Fossils from the Silurian and Devonian Rocks of Ontario (*Canadian Nat. and Geologist*, n. s., vol. vii, p. 230, figs. 1, 2).

The genus *Aulocopina* is defined, and its form and canal-structure is stated to resemble *Aulocopium*, Oswald. The spicular characters are unknown.

132. 1876 Zittel, K. A. Untersuchungen über fossile Spongien. Protokoll der Sitzung der deutschen geologischen Gesellschaft zu Jena, vom 14 August, 1876 (*Zeitsch. d. deutsch. geol. Gesellschaft*, Bd. 28, 1876, p. 629).

Prof. Zittel states that the majority of the so-called Petrosponges have undergone great alteration in their mineral structures in the course of fossilization, that the original silica of their skeletons has been replaced by calcite, and that owing to the delicacy of their siliceous fibres and the presence of axial canals, they become readily susceptible to the solvent influences of alkaline waters. A great part of the Petrosponges is stated to belong to the same group as the existing hexactinellids and lithistids, whilst in another division the fibres consisted originally of calcite.

133. 1876 Zittell, K. A. Untersuchung fossiler Hexactinelliden (*Neues Jahrbuch für Min.*, p. 286).

Announces in anticipation of his monograph on *Cœloptychium* the resemblance between the structure of this genus and *Ventriculites*, and states that the skeleton consists of amalgamated six-rayed spicules with a hollow octahedral node in the centre of each.

134. 1876 Kayser, E. Beiträge zur Geologie und Palaeontologie der argentinischen Republik (*Palæontographica*, Lief. iii, p. 22).

Refers generally to the fossil Sponges met with, and figures a small form, subsequently named by Zittel *Protachilleum Kayseri*.

135. 1876 Marck, v. der. Neue Beiträge zur Kenntniss der fossilen Fische und andern Thierreste aus der jungsten Kreide Westfalens (*Palæontographica*, Bd. xxii, p. 68, Pl. ii, fig. 10).

Describes as a new genus of Sponges, *Glenodictyum*, a fibrous body growing in the form of a hexagonal mesh-work. The minute structure cannot be recognised and the character of the fossil is very problematical.

136. 1876 Sollas, W. J. On *Eubrochus clausus*, a vitreo-hexactinellid Sponge from the Cambridge Coprolite Bed (*Geol. Mag.*, pp. 398—403, Pl. XIV).

Describes the form and compares its external structure with that of the existing genus *Farrea*, but the fossil Sponge is stated to possess an interior skeleton as well as an outer membrane.

137. 1876 Zittel, K. A. Ueber Coeloptychium. Ein Beitrag zur Kenntniss der Organisation fossiler Spongien (*Abh. der k. bayer. Akad. der Wiss.*, II Cl., xii Bd., iii Ab., pp. 1—80, Pls. I—VII).

An elaborate monograph on the general structure, the canal-system, and skeletal mesh of the Sponges of this genus. The nodes of the spicules are compared with those of the living genus *Myliusia*. The body of the Sponge is shown to consist of thin walls of spicular tissue disposed in radiating folds, which are enclosed in a cribriform dermal layer. Numerous detached spicules in the interior of these Sponges are erroneously regarded as belonging to their skeletal structures, but Zittell subsequently pointed out that their presence was accidental.

138. 1876 Armstrong, Young, and Robertson. Catalogue of the Western Scottish Fossils.

From the Upper Girvan series *Ischadites Kœnigii* is recorded, and *Hyalonema parallelum* and *Acanthospongia Smithii* from the Carboniferous of Ayrshire.

139. 1877 Carter, H. J. Note on the Tubulations sableuses of the Étage Bruxellien in the environs of Brussels (*Ann. and Mag. Nat. Hist.*, S. 4, vol. xix, pp. 382—393, Pl. 18).

The forms described by Rutot as Sponges are regarded by Carter as the tubes of a new type of Annelids. The siliceous spicules associated with them

are classified, and some are shown to be similar to those described by Carter from Greensand strata.

140. 1877 Carter, H. J. On a Fossil species of Sarcohexactinellid Sponge allied to Hyalonema (*Ann. and Mag. Nat. Hist.*, S. 4, vol. xx, p. 176).

A provisional notice of the presence of spicules of this group of Sponges in Carboniferous strata.

141. 1877 Young, J., and Young, J. On a Carboniferous Hyalonema and other Sponges from Ayrshire (*Ann. and Mag. Nat. Hist.*, S. 4, vol. xx, pp. 425—432, Pls. XIV, XV).

Numerous detached hexactinellid spicules, with others of anomalous form, and portions of elongated spicular rods, are regarded as belonging to a Sponge of the existing genus *Hyalonema.* Also a fibrous Sponge in which no spicules could be recognised is placed in a new genus, *Haplistion.*

142. 1877 Trautschold, H. Ueber Kreidefossilien Russlands (*Bull. de la Soc. imp. des nat. de Moscou*, vol. 52, p. 339, Pl. vi).

Describes various species which are placed in the genera *Cupulispongia*, *Porospongia*, and *Placuntarion.* Nothing is stated of their minute structures.

143. 1877 Zittel, K. A. Studien über fossile Spongien. 1 Abtheil., Hexactinellidæ (*Abhandl. d. k. bayer. Akad. der Wissenschaften*, II Cl., xiii Bd., pp. 1—63, Pls. I—IV).

Describes the systematic position, the condition of preservation, the characters, and the classification of fossil hexactinellids. Their skeletal structures are shown to possess the closest relationship to those of recent hexactinellids from the depths of the ocean, and they are very distinctly marked off from the Lithistids. Two main divisions are constituted (1) *Lyssakina*, in which the skeletal spicules are, as a rule, detached from each other, and only held in position by the sarcode; and (2) *Dictyonina*, in which the skeletal spicules are fused together in a regular manner, so as to form a connected lattice-like mesh with cubical or polyhedral interspaces. In this latter division are included the following families; *Astylospongidæ*, *Euretidæ*, *Coscinoporidæ*, *Mellitionidæ*, *Ventriculitidæ*, *Staurodermidæ*, *Mæandrospongidæ*, *Callodictyonidæ*, and *Cœloptychidæ*, whilst in the *Lyssakina* are included *Monakidæ*, Marshall; *Pleionakidæ*, Mars.; and *Pollakidæ*, Mars. Numerous new genera are proposed and diagnoses of them given.

144. 1877 Zittel, K. A. Beiträge zur Systematik der fossilen Spongien (Erster Th.) *Neues Jahrbuch*, pp. 337—378, Pls. II—V).

For the most part a reprint from the "Studien" referred to above.

145. 1877 Zittel, K. A. Studies on Fossil Sponges, I, Hexactinellida (*Annals and Mag. Nat. Hist.*, 4 S., vol. xx, pp. 257—273, 405—424, 501—517).

Translated by W. S. Dallas from the " Studien " in ' Abhand. d. k. bayer. Akad. der Wiss.,' II Cl., Bd. XIII.

146. 1877 Zittel, K. A. Untersuchungen über fossile Spongien (*Neues Jahrbuch*, pp. 705—709).

A short notice and criticism of the first part of vol. v of ' Quenstedt's Petrefaktenkunde.'

147. 1877 Sollas, W. J. On *Pharetrospongia Strahani*, a fossil Holorhaphidote Sponge from the Cambridge Coprolite Bed (*Quart. Journ. Geol. Soc.*, vol. xxxiii, pp. 242—255, Pl. xi).

Gives a minute description of its structural characters ; it is composed of anastomosing fibres, which consist of minute acerate spicules, closely arranged, generally parallel to one another. The forms are now nearly entirely calcareous, but in some cases a thin external film of the fibre with some of the spicules is siliceous. The Sponge is regarded as having originally been siliceous, and it is placed in the family *Renierida*.

148. 1877. Sollas, W. J. On the Structure and Affinities of the genus *Siphonia* (*Quart Journ. Geol. Soc.*, pp. 790—835, Pls. xxv, xxvi).

The minute structure of the skeleton is fully described; it is stated to consist of quadriradiate spicules with four diverging arms, bifurcating near their extremities and terminating in a number of rounded apophyses with intervening concavities. This structure is compared with that of the existing lithistid *Discodermia*. Details are given of the mineral changes produced by fossilization, including that of the replacement of the original silica by calcic carbonate, which had been already noted by Pomel and Zittel. *Siphonia* is placed in the family *Pachastrellidæ* and the order *Holorhaphidota*, Carter.

149. 1877 Sollas, W. J. On Stauronema, a new genus of Fossil Hexactinellid Sponges, with a description of its two species *S. Carteri* and *S. lobata* (*Ann. and Mag. Nat. Hist.*, S. 4, vol. xix, pp. 1—25, Pls. I—V).

Describes a fan-shaped Sponge with a very robust spicular mesh, the canals in which are stated to pass ordinarily from one node to another, and thus to differ from recent hexactinellids. The wall of the Sponge forms a thin, so-called oscular plate, which is overgrown at its base by a thick mass of irregular spicular tissue.

150. 1877 Martin, K. Untersuchungen über die Organization von *Astylospongia*, F. Roemer (*Archiv des Ver. der Freunde der Naturges. in Mecklenburg*, *Jahrg.* xxxi, pp. 1—32, Pl. 1).

Gives a lucid description of the canal-system, and points out that the number of the rays given off from each of the spicular nodes of the skeleton is not definitely six, as stated by Roemer, but that it varies from six to nine, and their arrangement is also without definite order; consequently the relationship between this genus and typical hexactinellids is somewhat doubtful.

151. 1876–78 Quenstedt, F. A. Petrefactenkunde Deutschlands, Bd. V. Korallen (Schwämme), pp. 1—612, with 28 folio plates.

No systematic arrangement of fossil Sponges is attempted; they are placed as a group under Corals. The descriptions are of a desultory character, and treat rather of individual peculiarities than of specific or generic features, and the employment of microscopic investigation is deprecated, as leading to erroneous ideas. The author gives new terms to genera and species, which in his opinion will indicate their characters, and arbitrarily rejects those previously applied to them. The main value of the work consists in its excellent illustrations of the external features of most of the known forms of fossil Sponges.

152. 1878 Carter, H. J. Mr. James Thomson's Fossil Sponges from the Carboniferous System of the South-West of Scotland (*Ann. and Mag. Nat. Hist.*, S. 5, vol. i, pp. 128—143, Pls. IX, X).

Treats first of the character of the spicules in *Hyalonema Smithii;* then points out that, owing to the fragile nature of the skeleton of calcisponges, it is almost impossible that *Pharetrospongia*, Sollas, could ever have belonged to this group. Further describes as a new siliceous Sponge *Pulvillus Thomsoni*, which is placed in the *Renierida*, the form is now calcareous; and *Rhaphidistia vermiculata* as a laminiform Sponge parasitic on *Hydractinia*.

153. 1878 v. Matyasowsky, J. Ein fossiler Spongit aus dem Karpathensandsteine von Kis-Lipnik im *Saroser comitate* (*Glenodictyum carpathicum*) (*Fermesyetragzi füsetek*, vol. ii, pt. 4, 1878. *Verh. der k. k. geolog. Reichsan. Wien*, p. 405).

Describes and figures a specimen belonging to the problematical genus, *Glenodictyum*, Marck.

154. 1878 Young, J. T. On the occurrence of a Fresh-water Sponge in the Purbeck Limestone (*Geol. Mag.*, n. s., vol. v, p. 220).

Describes and figures detached acerate microspined spicules in chert of fresh-water origin, which are referred to *Spongilla purbeckensis*.

155. 1878 Sollas, W. J. On the Structure and Affinities of the Genus Catagma (*Ann. and Mag. Nat. Hist.*, S. 5, vol. 2, pp. 353—364, Pl. XIV).

Describes the minute structure of some fibrous calcisponges from the Lower Greensand of Faringdon, which is stated to consist of two kinds of spicules, one kind uniaxial, arranged longitudinally in the exterior third of the fibre, the other kind multiradiate (three- or four-rayed), three of the rays occupying the interior or core of the fibre, the fourth directed outwardly and echinating the exterior of the fibre. The Sponges, in opposition to the views of Zittel, are regarded as siliceous, and placed as a new sub-family, the *Catagmidæ*, in the order *Rhaphidonemata*, Carter.

156. 1878 Trautschold. Ueber *Camerospongia Auerbachi*, Eichwald (*Zeitschr. d. deutsch. Geol. Gesell*, Bd. 30, pp. 225—228, Pl. IX).

Shows that this Sponge properly belongs to the genus *Cœloptychium*, Goldf.

157. 1878 Carter, H. J. Emendatory description of *Purisiphonia Clarkei*, Bowerb., a Hexactinellid Fossil Sponge from N. W. Australia (*Ann. and Mag. Nat. Hist.*, S. 5, vol. i, p. 376).

Gives details of the structure and of the form of the flesh-spicules.

158. 1878 Bigsby, J. J. Thesaurus Devonico-Carboniferus.

Under *Amorphozoa* there are twenty-five species enumerated, but not more than five or six of these are true fossil Sponges.

159. 1878 Martin, K. Niederlændische und nordwest-deutsche Sedimentær-Geschiebe, pp. 63—68, Pl. I.

Describes a new species, *Aulocopium variabile*, and as a new genus and species *Silurispongia conus*, but the spicular structure of this form is unknown, and the generic characters are, therefore, of little value.

160. 1878 Wallace, S. On the Geodes of the Keokuk Formation (*American Journ. Science*, S. 3, vol. xv, pp. 366—370).

These bodies are believed to be Sponges, and formed into a new genus, named *Biopalla*, including numerous species. No figures are given, and the evidence brought forward is altogether insufficient to establish their alleged origin.

161. 1878 Etheridge, R., Junr. Palæontological Notes (*Geol. Mag.*, Dec., ii, vol. V, p. 119).

Records fresh localities in the East of Scotland where the anchoring rope of *Hyalonema parallelum* = *Hyalostelia Smithii*, Young and Young occurs, and notices a more delicate form, proposed to be named *H. Youngi*, but which is probably the true *H. parallelum*, of M'Coy.

162. 1878 ZITTEL, K. A. Zur Stammes-Geschichte der Spongien (*Festschrift zum Jubiläum des Prof. von Siebold*, pp. 1—20).

Refers to the recent investigations into the embryology of living Sponges as proving their Metazoal character. Sponges generally are ranked under seven orders, *Myxospongiæ*, *Ceraospongiæ*, *Monactinellidæ*, *Tetractinellidæ*, *Lithistidæ*, *Hexactinellidæ*, and *Calcispongiæ*. The geological history of Sponges is given, and it is shown that even in the Palæozoic period six of the main orders were present, and even then distinctly marked off from each other, so that there is no palæontological evidence to show the original stock from which they have descended.

163. 1878 ZITTEL, K. A. Ueber Jura-Spongien (*Neues Jahrbuch*, pp, 58—62).

Reference is made to the descriptions and figures of Jurassic hexactinellid Sponges in Heft 2 of vol. v of Quenstedt's Petrefaktenkunde, and they are compared with those described by Zittel in the "Studien," pt. 1.

164. 1878 ZITTEL, K. A. Studien über fossile Spongien, 2te Abtheilung, Lithistidæ (*Abh. der k. bayer. Akad. der Wiss.*, II Cl., xiii Bd., pp. 67—154, Pls. I—X).

Shows that a large group of fossil Sponges possessed the same spicular structures as the recent Lithistids of Oscar Schmidt. Their spicular characters are described in detail, and the order is divided according to the character of their elementary spicules into the following four families, *Rhizomorina*, *Megamorina*, *Anomocladina*, and *Tetracladina*. In each of these families new genera are proposed, based mainly on the character of the canal-system, and modifications of their dermal surfaces. The structural characters are fully illustrated.

165. 1878 ZITTEL, K. A. Beiträge zur Systematik der fossilen Spongien. 2te. Th. Lithistiden (*Neues Jahrbuch*, pp. 561—618, Pls. VII—X).

A reprint from the "Studien" in 'Abh. d. k. bayer. Akad. d. Wiss.,' II Cl., xiii Bd.

166. 1878 ZITTEL, K. A. Studies on Fossil Sponges, II, Lithistidæ (*Ann. and Mag. Nat. Hist.*, S. 5, vol. ii, pp. 113—135, 235—248, 324—341, 385—394, 467—482, Pl. VIII).

Translated by W. S. Dallas from the "Studien" in 'Abh. d. k. bayer. Akad. der Wiss.,' II Cl., Bd. xiii, Abth i, pp. 67—154.

167. 1878 ZITTEL, K. A. Studien über fossile Spongien, 3tte Abtheilung, Monactinellidæ, Tetractinellidæ, und Calcispongiæ (*Abh. der. k. bayer. Akad. der Wiss*, II Cl., xiii Bd., II Ab., pp. 93—138, Pls. XI—XII).

Fossil Monactinellid Sponges are shown to be a small and unimportant

group. Two new genera are proposed, *Opetionella* and *Scoliorhaphis*. The Tetractinellidæ are likewise rarely found as entire Sponges, though their spicules occur even in Carboniferous Rocks. A new species of *Pachastrella* is described, and a new genus *Tethyopsis*. Fossil calcisponges are shown to be very numerous. The views of Haeckel and Carter that Sponges of this group could not be preserved as fossils are discussed and regarded as erroneous. With the exception of a single form, *Protosycon*, fossil calcisponges belong to a distinct family, characterised by a skeletal structure of anastomosing fibres. These fibres are built up of minute uniaxial and three-rayed spicules, comparable to those of existing calcisponges. It is shown that these fossils are not, as stated by Carter and Sollas, siliceous Sponges which have been replaced by calcite. In the new family, *Pharetrones*, several new genera are introduced, as well as many genera of previous authors, including *Pharetrospongia*, Sollas.

168. 1878 Zittel, K. A. Handbuch der Palaeontologie, Bd. i, II Lief.

Descriptions are given of the various groups of fossil Sponges, similar to those in the " Studien." Diagnoses of all the genera are given, and illustrations of the typical forms. The genus *Hyalostelia* is proposed to include *Hyalonema Smithii*, Young.

169. 1878 Sollas, W. J. Notes on the Ventriculites of the Chalk (*Dixon's Geology of Sussex*, New Edition, pp. 448—455, Pls. XLVI—LI).

Describes the spicular structure and other characters of the genus; the former is compared with the structure of the recent hexactinellid, *Myliusia Grayi*.

170. 1879 Zittel, K. A. Beiträge zur Systematik der fossilen Spongien. Dritter Th., *Neues Jahrbuch*, pp. 1—40, Pls. I, II.

Mostly a reprint from Abhand. der k. bayer. Akad der Wiss., II Cl., xiii Bd.

171. 1879 Zittel, K. A. Studies on Fossil Sponges, III, IV, V, Monactinellidæ, Tetractinellidæ, and Calcispongiæ (*Ann. and Mag. Nat. Hist.*, S. 5, vol. iii, pp. 304—312, 364—379; also vol. iv, pp. 61—73, 120—135.

Translated by W. S. Dallas from the " Studien," Dritte Abth.

172. 1879 Nicholson, H. A. Manual of Palaeontology, 2nd Edition.

The first part of the volume was written before the works of Zittel were fully published, and consequently it is mainly interesting as indicating the generally received views held at the time on fossil Sponges. *Astræospongia*, *Amphispongia*, and provisionally *Stromatopora* and *Archæocyathus* are included with calcisponges. Zittel's classification is adopted for fossil siliceous

Sponges. *Receptaculites, Ischadites*, and *Tetragonis* are regarded as aberrant types of Foraminifera.

173. 1879 Sinzow, J. On Calcareous Sponges from the Government of Saratow (Russian) (*Trans.* (*Zapiski*) *New Russian Nat. Hist. Soc.*, vol. vi, pp. 1—40).

174. 1879 Carter, H. J. On Holasterella, a Fossil Sponge of the Carboniferous Era, &c. (*Ann. and Mag. Nat. Hist.*, S. 5, vol. iii, pp. 141—150, Pl. XXI).

Describes a club-shaped Sponge, which is stated to be built up of stellate spicules, with normally twelve rays or arms. The genus is placed in the Suberitida, under *Holorhaphidota*.

175. 1879 Mazzetti e Manzoni. Le Spugne fossile di Montese (*Atti. de la Soc. Toscani dei sci. nat.*, vol. iv, p. 57, 2 pls.).

The existence is shown of hexactinellid and lithistid Sponges in the Montese marls, which are of Miocene age. Their skeletal structures have been replaced by calcite. The species are not determined.

176. 1879 Hannay, J. B. On Siliceous Fossilisation (*Mem. of the Lit. and Phil. Soc. of Manchester*, S. 3, vol. vi, p. 234).

Describes the present state of preservation of the spicules of *Hyalonema Smithii* and traces the various changes in the silica arising from fossilisation.

177. 1879 Woeckener, H. Ueber das Vorkommen von Spongien im Hilssandstein. Zusatz zu vorstehendem Aufsatz, von Herrn Zittel (*Zeitsch d. deutsch. geol. Gesell.*, Bd. 31, pp. 663—667).

Large, irregular, siliceous masses, numerous in the Sandstone, are regarded as siliceous Sponges, but Zittel points out that these are not Sponges, though they result from the solution of the detached spicules of Sponges, of which negative casts remain. The rock is therefore a Sponge deposit mostly of monactinellid spicules. Zittel records similar deposits in the Upper Lias of the Tyrol, and in the Rhætic of Upper Bavaria, as well as in the Cretaceous strata of Westphalia.

178. 1879 Duncan, P. M. On some Spheroidal Lithistid Spongida from the Upper Silurian Formation of New Brunswick (*Ann. and Mag. Nat. Hist.*, S. 3, vol. iv., pp. 84—91, Pl. IX).

The structure of a new genus, *Hindia*, is described and figured. It is stated to be built up of tripod-shaped spicules, but the sponge is regarded as having originally been composed of carbonate of lime.

179. 1880 Sollas, W. J. On the Structure and Affinities of the genus *Protospongia* (*Quart. Journ. Geol. Soc.*, vol. xxxvi, pp. 362—367, figs. 1, 2).

Describes the form and arrangement of the spicules; they are regarded as separate, and not united either by envelopment in a common coating or by ankylosis; the Sponge is consequently placed in the Lyssakina division of Zittel.

180. 1880 Sollas, W. J. On the Flint Nodules of the Trimingham Chalk (*Annals and Mag. Nat. Hist.*, vol. vi, pp. 384—395, 437—461, Pls. XIX, XX).

Describes various forms of detached spicules of Tetractinellid and Lithistid Sponges obtained from the soft chalk surrounding the flints. The spicules are for the most part placed in new genera and species.

181. 1880 Gümbel, C. W. Spongien-Nadeln im Flysch. (*Verh. d. k. k. geol. Reichsan. Wien*, pp. 213—215).

States that in many localities the "Flysch" of the North-eastern Swiss and Bavarian Alps is largely composed of detached Sponge-spicules; they are invariably present in a peculiar, fine-grained, siliceous limestone. Notices also, that rocks of Neocomian age from Rossfeld, and certain strata of Lias age from Algäu and elsewhere are similarly composed of an aggregate of Sponge-spicules.

182. 1880 Carter, H. J. On Fossil Sponge-Spicules from the Carboniferous strata of Ben Bulben near Sligo (*Ann. and Mag. Nat. Hist.*, vol. vi, pp. 209—214, Pl. XIV, B).

Describes detached spicules of *Reniera* and of a lithistid Sponge, and also hexactinellid spicules with bifurcate and spiral rays, which are referred to *Holasterella*.

183. 1880 Steinmann, G. Mikroskopischen Thierreste aus dem deutschen Kohlenkalk (*Zeitsch. d. deutschen geol. Gesell.*, Bd. 32, p. 395, Pl. XIX).

Describes and figures an umbrella-shaped spicule from the Carboniferous Limestone of Ratingen near Dusseldorf, under *Hyalostelia Smithii*.

184. 1880 Hinde, G. J. Fossil Sponge-Spicules from the Upper Chalk, pp. 1—83, Pls. I—V.

Describes and figures a great variety of detached spicules, obtained from the interior of a flint nodule. These are referred to different genera of monactinellid, tetractinellid, lithistid, and hexactinellid Sponges.

185. 1880 Roemer, Ferd. Lethæa geognostica (1 Th., *Lethæa palæozoica*).

The family *Receptaculitidæ* is placed provisionally with Foraminifera, and *Dictyophyton* is regarded as similar to *Tetragonis*. The following genera are described as true palæozoic Sponges, *Astylospongia*, *Palæomanon*, *Prota-*

chilleum, *Aulocopium*, *Astræospongia*, *Protospongia*, and *Acanthospongia;* and references are given to the species described. *Brachiospongia, Acestra, Bothroconus*, and some other genera are regarded as doubtful.

186. 1881 Sollas, W. J. On *Astroconia Granti*, a new Lyssakine Hexactinellid from the Silurian Formation of Canada (*Quart. Journ. Geol. Soc.*, vol. xxxvii, pp. 254—260, figs. 1—11).

Describes various forms of detached acerate and hexactinellid spicules, which are referred to this new genus and species.

187. 1881 Sollas, W. J. Note on the Occurrence of Sponge-Spicules in Chert from the Carboniferous Limestone of Ireland (*Ann. and Mag. Nat. Hist.*, vol. vii, pp. 141—143, fig. 1).

Mentions the occurrence, in some cases in great abundance, of spicules in microscopic sections of chert, which had been described by Prof. Hull as of inorganic origin.

188. 1881 Whitfield, R. P. Observations on the Structure of Dictyophyton and its Affinities with certain Sponges (*American Journ. of Science*, vol. xxii, pp. 53, 132).

The structure of this organism, which had been referred by Hall to Algæ, is compared to that of the recent *Euplectella*, and it is supposed to have consisted of siliceous fibres, although positive evidence for this is at present wanting.

In a subsequent note an example of *Uphantænia* is described, in which the spicules forming the longitudinal and transverse bundles are now preserved in the condition of pyrite, and the rectangular spaces between the bundles are also covered with a thin film of the same substance.

189. 1880 Nicholson and Etheridge, Junr. A Monograph of the Silurian Fossils of the Girvan District.

A description is given of *Ischadites Kœnigii*, Murch.; its systematic position is regarded as doubtful; the siliceous rope of a Sponge is described under the name of *Hyalonema* (?) *Girvanense* (p. 239, Pl. xix, figs. 1, 1 *b*).

190. 1881 Whitfield, R. P. Remarks on Dictyophyton and descriptions of new species of allied forms from the Keokuk Beds at Crawfordsville, Indiana (Bulletin No. 1, *American Mus. Nat. Hist.*, p. 10, Pls. 3, 4).

Refers to the different names applied to this genus from time to time, and gives detailed descriptions of species of *Uphantænia* and *Dictyophyton.* The structure is stated to consist of longitudinal and transverse fibres or threads, formed of bundles of cylindrical spicula.

191. 1881 Walcott, C. D. On the Nature of Cyathophycus (*Amer. Journ. Science*, vol. 22, p. 394).

Its structure is stated to consist of narrow bands forming a horizontal and a perpendicular series, which cross each other at right angles. The bands are composed of threadlike spicula, now of pyrites. Two species are described. No reference is made to the form of the individual spicules beyond that they are threadlike.

192. 1881 Steinmann, G. Ueber *ProtetraclisLinki*, n. f. eine Lithistide des Malms (*Neues Jahrbuch*, Bd. ii, pp. 154—163, Pl. IX).

Describes a lithistid in which there is considerable variety in the form of the skeletal spicules. It is regarded as a genuine Tetracladine. The author also refers the Silurian genus *Aulocopium* to the same family.

193. 1882 Hinde, G. J. Notes on Fossil Calcispongiæ, with descriptions of new species (*Ann. and Mag. Nat. Hist.*, vol. x, pp. 185—205, Pls. X—XII).

Records the discovery in fossil *Pharetrones*, from the Upper Greensand, of three- and four-rayed spicules, which can be detached from the matrix, and are clearly identical in form with those of recent calcisponges. Some of them also occupy a similar relative position on the dermal surface of the Sponge. A specialised three-rayed spicule, in the shape of a tuning-fork, is present in the fossil genus *Sestrostomella;* it closely resembles a spicule in an existing Australian calcisponge. These facts clearly establish that the *Pharetrones* are, as Zittel claimed them to be, true calcisponges.

194. 1882 Steinmann, G. Pharetronen-Studien (*Neues Jahrbuch*, Bd. ii, pp. 139—191, Pls. VI—IX.

This paper, which appeared almost simultaneously with that by Hinde mentioned above, contains the results of the author's five years study of the group. The *Pharetrones* are regarded as having been originally calcareous, their spicular elements are stated not to resemble those of recent calcisponges, since, amongst other reasons, no axial canals can be detected in them, and the recent spicules are stated to be so delicate as readily to melt in distilled water in a few seconds. Their structures are finally compared to those of *Alcyonaria.* Subsequent investigations have shown that the author's theories respecting the group are altogether erroneous.

195. 1882 Zittel, K. A. Notizen über fossile Spongien (*Neues Jahrb.*, ii Bd., p. 203).

Confirms Hinde's observations on the spicular structure of *Corynella* and other *Pharetrones*, and regards their character as calcisponges to be fully

proved. Regards *Protospongia* and *Dictyophyton* as belonging to dictyonine hexactinellids.

196. 1882 Munier-Chalmas. Barroisia, n. g. des Eponges (*Bulletin Soc. Géol. de France*, S. 3, vol. x, p. 425).

Proposes this name for what he states is the *Tubipora anastomosans*, Mant. No other characters, but those of the outer form, are given, and there is no reference to the description of *T. anastomosans.*

197. 1882 Manzoni, A. La struttura microscopica delle Spugne silicee del Mioceni medio di Bologna e di Modena, pp. 1—24, Pls. I—VII.

Describes in detail the condition of preservation, and the structural characters of several species of hexactinellid and lithistid Sponges, which are placed under Zittel's classification. The forms are well illustrated.

198. 1882 Dunikowski, E. Die Spongien der unterliassischen Schichten von Schafberg bei Salzberg (*Denks. d. k. Akad. der Wiss. Wien*, Bd. 45, pp. 163—194, Pls. I—IV).

Describes and refers to different genera numerous detached spicules of monactinellid, tetractinellid, and lithistid Sponges, as well as portions of hexactinellid meshwork, which occur, heterogenously mingled together, in cherty limestones of Lower-Lias age.

199. 1883 Keeping, W. The Fossils of the Neocomian Deposits of Upware and Brickhill.

Amongst these are twelve species of Sponges; one is referred to *Plocoscyphia*, and the others belong to the family *Pharetrones.* The author does not express a decided opinion as to the nature of these latter, though he rather favours the opinion of Prof. Sollas that they are siliceous Sponges which have been replaced by calcite.

200. 1883 Klemm, E. Ueber alte und neue Ramispongien und andere verwandte Schwammformen aus der Geislinger Gegend (*Jahreshft. Ver. f. vaterl. Naturk. Württemb.*, vol. xxxix, pp. 243—308).

Describes numerous Sponges from the White Jura which are all included in the undefined genus *Ramispongia*, Quenst. They are stated to be mostly hexactinellids. The specific characters are based on outer form and are apparently of little scientific value. No figures given.

201. 1883 Dunikowski, E. Die Pharetronen aus dem Cenoman von Essen, und die Systematischen Stellung der Pharetronen (*Palæontographica*, Bd. 29, pp. 283—323, Pls. XXXVII—XL).

Describes in detail the spicular structures and other characters of these forms, and concludes that not only are they fossil calcisponges, but that their

structure agrees so closely with that of the existing family of *Leucones*, Hæck., that they should properly be included in it. Further, regards the fibres of these Sponges as not original structures but of secondary origin, produced wholly by the process of fossilization. Refutes in detail the objections raised by Steinmann to their spongeous nature, and fully confirms the previous results of Zittel and Hinde.

202. 1883 Carter, H. J. Further Observations on the so-called 'Farringdon Sponges' (Calcispongiæ, Zittel), followed by a description of an existing species of a like kind (*Ann. and Mag. Nat. Hist.*, S. 5, vol. xi, pp. 20—37, Pl. I).

Confirms the observations of Hinde on fossil calcisponges, and acknowledges that they are rightly referred to this group. Thinks, however, that *Pharetrospongia Strahani*, Sollas, and some species of *Stellispongia*, in which only acerate spicules have been detected, cannot be claimed as calcisponges, but that they are siliceous Sponges with their structures replaced by calcite. Describes a recent form, *Leucetta clathrata*, in which the fibres are solid, as in the *Pharetrones*.

203. 1883 Carter, H. J. Spicules of Spongilla in the Diluvium of the Altmühl Valley, Bavaria (*Ann. and Mag. Nat. Hist.*, S. 5, vol. xii, pp. 329—333, Pl. XIV).

Detached spicules of the body-skeleton and of the gemmules are recognised as belonging to *Meyenia* (*Spongilla*) *erinacea*, Ehr.

204. 1883 Carter, H. J. On the Microscopic Structure of thin slices of Fossil Calcispongiæ (*Ann. and Mag. Nat. Hist.*, S. 5, vol. xii, pp. 26—30).

Refers to projecting pin-like spicules on the surface of *Verticillites anastomosans*, Mant., and to the changes in the fossilization of Pharetrones.

205. 1883 Sollas, W. J. The Group Spongiæ (*Cassell's Natural History*, vol. vi, pp. 312—331, figures).

Refers nearly exclusively to recent Sponges and only the geological appearance of the fossil forms mentioned. States that no fossil Sponge unquestionably belonging to the Calcispongiæ has, up to this time, been described. The Monaxonidæ, on the evidence of Cliona borings, are concluded to have been in existence in early Palæozoic times; *Pharetrospongia Strahani* is said to be a large Renierine Sponge, the best preserved and most certainly demonstrated example yet known; the Lithistidæ are said to occur from the Upper Cambrian to the Tertiary, and the Hexactinellidæ from the Lower Cambrian upwards.

206. 1883 Roemer, Ferd. Notiz über die Gattung Dictyophyton (*Zeitsch. d. deutsch. Geol. Gesell.*, p. 704).

Points out the resemblance of *Tetragonis Eifeliensis* to the genus *Dictyophyton*, and describes as new, *Dictyophyton Gerolsteinense*, which appears to be only the interior of *Sphærospongia tessellata*, Phill. sp. The author doubts that these fossils can have been siliceous Sponges, since their siliceous skeletons would have been preserved, but thinks that probably they may have possessed skeletons of a horny character like the existing Gorgonias.

207. 1883 Walcott, C. D. Fossils of the Utica Slate (*Transactions of the Albany Institute*, vol. x). Paper stated to have been read March, 1879.

Cyathophycus, subsequently recognised as a Sponge, is here described, figured, and named as a genus of Algæ, of reticulate or plain structure, and consisting of hollow membranous fronds (p. 18, Pl. ii, figs. 16, 17).

208. 1883 Linck, G. Zwei neue Spongiengattungen (*Neues Jahrb. für Min.*, II Bd., 1ster Heft, pp. 59—62, Pls. II, III).

In one genus, *Didymosphæra*, the skeletal spicules consist of twin nodes connected by a straight rod with axial canal, and there are from three to five rays given off from each node. This form is considered as the typical elementary spicule of the Anomocladina family. The spicules become modified so as to resemble those of the Rhizomorina family. The other genus has spicules of the Rhizomorina type; it is named *Polyrhizopora*.

209. 1883 Barrois, C. Sur les Dictyospongidæ des Psammites du Condroz (*Ann. de la Soc. Géol. du Nord*, T. xi, pp. 80—86, Pl. 1).

Describes and figures two species of *Dictyophyton* from the Upper Devonian of the Ardennes, and places them as dictyonine hexactinellids.

210. 1883 Hinde, G. J. Catalogue of the Fossil Sponges in the British Museum. pp. 1—248, Pls. I—XXXVIII.

Descriptions are given of the British species, and of new species from foreign localities, which are figured. The classification of Zittel is followed. The following new genera of monactinellids are proposed: *Climacospongia*, *Lasiocladia*, and *Acanthorhaphis*. The new genera of lithistids are *Placonella*, *Holodictyon*, *Pachypoterion*, *Nematinion*, *Bolospongia*, *Kalpinella*, *Thamnospongia*, *Pholidocladia*, *Phymaplectia*, and *Rhopalospongia*. The genus *Astylospongia* is placed provisionally in the Hexactinellida, but it is suggested that its minute structure resembles more closely that of the Anomocladine lithistid, *Cylindrophyma*. The new genera of hexactinellids are *Strephinia*, *Sestrodictyon*, *Sestrocladia*, *Placotrema*, *Cincliderma*, *Plectoderma*, *Porochonia*, and *Sclerokalia*. The following genera of calcisponges are introduced:

Tremacystia, Inobolia, Trachysinia, Diaplectia, and *Rhaphidonema.* The author maintains the view of Zittel that the Pharetrones are a distinct family from the existing Leucones, and regards their fibrous structures as original, and not, as stated by Dunikowski, produced merely by fossilization.

211. 1883 Sollas, W. J. Descriptions of Fossil Sponges from the Inferior Oolite, with a notice of some from the Great Oolite (*Quart. Journ. Geol. Soc.*, vol. xxxix, pp. 541—554, Pls. XX, XXI).

Describes as new genera of hexactinellid Sponges, *Emploca, Mastodictyum, Plectospyris*, and *Calathiscus*, also a new species *Leptophragma fragile.* A new species of lithistid, *Platychonia elegans*, and several species of Pharetrones, as well as a new genus *Thamnonema*, are also described.

212. 1883–84 Počta, P. Beiträge zur Kenntniss der Spongien der böhmischen Kreideformation. I Ab., Hexactinellidæ, sep. cop., pp. 1—42, Pl. 3; II Ab., Lithistidæ, sep. cop., pp. 1—45, 2 Pls. (*Abhandlung. der Königl. böhm. Gesell. der Wiss.*, vi Folge, 12 Bd.).

These memoirs give the results of a thorough investigation into the minute structures and other characters of the Sponges from the Cretaceous strata of Bohemia, the superficial characters of many of which had already appeared in the works of Reuss. Zittel's classification is adopted. In addition to many new species of existing genera, the following new genera of hexactinellids are proposed: *Petalope, Synaulia, Lopanella, Botroclonium*, and *Cyrtobolia.* The only new genus of lithistids is named *Paropsites.* Figures are given of the new forms and of their spicular structures.

213. 1883 Počta, P. Einige Bemerkungen über das Gitterskelet der fossilen Hexactinelliden (*Sitzungsb. der Königl. böhm. Gesells. der Wiss. Prag. Jahrg.* 1882, p. 378).

Gives a detailed description of the spicular structure of this group of Sponges, and of its modifications in different genera.

214. 1884 Dunikowski, E. Ueber Permo-Carbon. Schwämme von Spitzbergen (*Kongl. Svenska. Vetensk. Akad. Handl.*, Bd. 21, sep. cop., pp. 1—18, Pl. LII).

The Sponges are stated to be of a fibrous character, and the fibres are composed of monactinellid spicules. They are placed in a new genus, *Pemmatites*, and divided into four species and varieties. Their state of preservation is so unfavorable that there is room for doubting whether their true characters have been ascertained.

215. 1884 Zittel, K. A. Ueber Astylospongidæ und Anomocladina (*Neues Jahrb. f. Min.*, Bd. ii, pp. 75—80, Pls. I, II.

From further study the author sees reason to alter his former views

respecting the skeleton of *Astylospongia*, and now regards it as consisting of simple rodlike spicules branching at both ends. By the interlocking of the branching extremities the nodes are formed. The family *Astylospongidæ* is removed from the Hexactinellidæ and placed with the Anomocladine family of lithistids. The previous definition of the characters of this family is altered, and the elementary spicules of the skeleton are stated to consist of simple, straight or curved, rod-like spicules with branching extremities. In the family are included *Astylospongia*, *Palæomanon*, *Protachilleum*, *Eospongia*, *Melonella*, *Cylindrophyma*, *Mastosia*, and the existing genus *Vetulina*. The genus *Didymosphæra*, Link, is regarded as equivalent to *Cylindrophyma*, Zitt. *Lecanella*, Zitt., and *Hindia*, Dunc. are placed in the family *Megamorina*.

216. 1884 Počta, P. Ueber isolirte Kieselspongiennadeln, aus der böhm. Kreideformation. Ueber Spongiennadeln des Brüsauer Hornsteines (*Sitzungsber. der. k. böhm. Gesell. der Wiss.*, pp. 1—14, 243—254, 3 pls).

Numerous detached spicules of tetractinellid, lithistid, and also of hexactinellid Sponges are described and figured. Many are similar to those occurring in the Cretaceous strata of England.

217. 1884 Hinde, G. J. On the Structure and Affinities of the Family of the Receptaculitidæ, including therein the genera Ischadites, Murch. (= Tetragonis, Eichw.); Sphærospongia, Pengelly; Acanthochonia, gen. nov., and Receptaculites, Defrance (*Quart. Journ. Geol. Soc.*, vol. xl, pp. 795—849, Pls. XXXVI—XXXVII).

These fossils are regarded as siliceous hexactinellid Sponges in which one ray of the regular spicule is modified to form a rhomboidal or hexagonal plate. The history and geological distribution of the genera are given, as well as a revision of the different species.

218. 1884 Hinde, G. J. On Fossil Calcisponges from the Well-boring at Richmond (*Quart. Journ. Geol. Soc.*, vol. xl, pp. 778—783, Pl. XXXV).

Describes several new species of minute Sponges, in some of which the spicular structure can be distinguished in thin sections. The strata from whence they come are probably of Jurassic age.

219. 1884 Hall, James. Descriptions of the Species of Fossil Reticulate Sponges, constituting the Family Dictyospongidæ (*Thirty-fifth Annual Report of the New York State Museum*, pp. 465—481, Pls. 18—21).

These bodies are described as fronds consisting of a reticulation of tubular spicules forming rectangular meshes, which alternate in size and strength, owing to the alternation in the size of the bundles of spicules. Three layers are stated to be present. Nothing is stated of the form of the spicules. The

following genera are proposed; their characters are mainly based on the external form of the bodies; *Cyathophycus, Dictyophyton, Ectenodictya, Lyrodictya, Thamnodictya, Phragmodictya, Cleodictya, Physospongia*, and *Uphantænia*.

220. 1884 Hoernes, R. Elemente der Palæontologie.

Fossil Sponges are placed under Cœlenterata. The classification and descriptions of Zittel are closely followed, and the figures are likewise nearly all borrowed from the works of the same author.

221. 1884 Carter, H. J. On the *Spongia coriacea* of Montagu = *Leucosolenia coriacea*, Bowk., together with a new variety of *Leucosolenia lacunosa*, Bowk., elucidating the spicular structure of some of the Fossil Calcispongiæ, followed by illustrations of the pinlike spicules on *Verticillites helvetica*, De Loriol (*Ann. and Mag. Nat. Hist.*, vol. xiv, pp. 17—29, Pl. I).

Describes the stem of *Leucosolenia lacunosa*, var. *Hillieri*, as solid and formed of central triradiates with an outer layer of minute vermiform triradiate spicules, similar to those of many fossil Pharetrones.

222. 1885 Počta, P. Beiträge zur Kenntniss der Spongien der böhm. Kreideformation. III Abtheil., Tetractinellidæ, Monactinellidæ, Calcispongiæ, Ceratospongiæ, Nachtrag (*Abhandl. der k. böhm. Gesells. der Wissen.*, vii Folge, 1 Band, sep. cop., pp. 1—40, Pl. I).

Numerous forms of detached spicules belonging to the two first-named orders are described; they resemble closely those occurring in strata of the same age in England and Germany. Many new species of calcisponges are described, but in most instances the microscopical structure cannot be recognised. A new genus *Parenia* is also proposed. The author opposes the view of Dunikowski respecting the secondary origin of the fibres in the family Pharetrones. Reference is made to casts of branching cylindrical bodies, supposed to be *Ceratospongiæ*, but there are no evidences of organic structure in them to support the theory.

223. 1885 Schlüter, C. Ein schon länger bekannte Spongie des rheinischen Devon (*Sitzungsber. der niederrh. Gesells. in Bonn*, p. 151).

Constitutes a new genus *Octacium*, for detached eight-rayed spicules hitherto included under *Astræospongia*.

224. 1885 Quenstedt, F. A. Handbuch der Petrefaktenkunde, 3rd Ed.

Sponges are treated in the same desultory manner as in the 'Petrefakten Deutschlands' of the same author; no definite classification is introduced; and they are for the most part ranged in the obsolete genera of Goldfuss and

Schweigger. Fossil calcisponges do not appear to be even named, and *Stromatopora* is still retained in the Sponges.

225. 1885 Sollas, W. J. On the Physical Characters of Calcareous and Siliceous Sponge-spicules and other Structures (*Scientific Proc. Royal Dublin Soc.*, n. s., vol. 4, pp. 374—392, Pl. XV).

Describes methods for determining the refractive-index and specific gravity of spicules of siliceous and calcareous sponges; treats also of the optic axis and angles of extinction, and of the effects of etching of calcisponge spicules. States that the Pharetrones must now be relegated to the Calcispongiæ; but *Pharetrospongia* is certainly a siliceous Sponge. Many spicules of calcisponges are shown to be elliptical in transverse section.

226. 1885 Sollas, W. J. On an Hexactinellid Sponge from the Gault, and a Lithistid from the Lias of England (*Scientific Proc. Royal Dublin Soc.*, vol. 4, pp. 443—446, Pl. XXI).

Describes as new species *Platychonia Brodiei* and *Craticularia calathus*. Figures are given of their form and structures.

227. 1885 Sollas, W. J. On Vetulina stalactites, O. Schmidt, and the Skeleton of the Anomocladina (*Proc. Roy. Ir. Acad.*, S. 2, vol. iv, pp. 486—492, Pls. III, IV).

Shows that the elementary spicules of this recent species consist, as O. Schmidt described them, of central nodes from which a variable number of rays extend, and concludes that the spicules of *Astylospongia* and other fossil *Anomocladina* are of a similar character. The views of Zittel that the elementary spicules of this family are simple rodlike spicules with branching extremities are thus shown to be untenable. Gives a fresh definition of the family *Anomocladina*, similar to that first proposed by Zittel in the 'Studien.'

228. 1885 Počta, P. Ueber zwei neue Spongien aus der böhmischen Kreideformation (*Sitzungsb. d. k. böhm. Gesell. der. Wiss.* sep. copy, pp. 1—7, Pl. 1).

Describes and figures as two new species *Casearia cretacea* and *Verrucocœlia uvæformis*.

229. 1885 Kayser, E. *Lodanella mira*, eine unterdevonische Spongie (*Zeitsch. d. deutsch. geol. Gesell.*, pp. 207—211, Pl. XIV).

The form thus named consists of the negative casts of a funnel-shaped body whose walls were penetrated by anastomosing canals. No structure whatever has been preserved, and the character of the organism cannot therefore be determined.

230. 1885 Hinde, G. J. On Beds of Sponge-remains in the Lower and Upper Greensands of the South of England (*Phil. Trans. Roy. Soc.*, Pt. II, pp. 403—453, Pls. 40—45).

Strata of chert and siliceous rock are shown to consist mainly of various forms of detached spicules of siliceous Sponges. These spicules principally belong to tetractinellid and lithistid Sponges, but monactinellid and hexactinellid Sponges are also represented. The spicules are figured and described, and reference is made to the changes produced in their structures by fossilization.

231. 1882–1885 Vosmaer, G. C. J. Porifera (*Bronn's Klassen und Ordnungen des Thier-Reichs*, Lief. 1—11).

The work mainly treats of recent forms. The Porifera, fossil and recent, are divided into two classes: (1) *Porifera calcara*, and *P. non-calcarea*. In this latter are included (Order 1) Hyalospongiæ (= Hexactinellidæ); (2) Spiculispongiæ (= Lithistidæ, Tetractinellidæ, Myxospongiæ, Monactinellidæ, pars); (3) Cornacuspongiæ (= Monactinellidæ, pars, Ceratospongiæ). Zittel's classification is mainly followed in the subdivisions of the fossil forms.

232. 1885 Feistmantel, Karl. Spongien-Reste aus silurischen Schichten von Böhmen (*Sitzungsb. d. Königl. böhms. Gesell. d. Wiss. in Prag. Jahrg.* 1884, p. 100).

Records the occurrence of detached complete six-rayed hexactinellid spicules, in cherty rock of Lower Silurian (Cambrian ?) age in various localities in Bohemia.

GENERAL CHARACTERS.

Sponges may be defined generally as animals with bodies of very variable form and size, consisting principally of a soft fleshy mass enclosed in a delicate skin. The body is penetrated by a system of canals and minute chambers which communicate with the exterior by larger, and numerous smaller, apertures. With few exceptions they secrete a skeleton, either of horny fibres or of siliceous or calcareous spicules.

Only the skeletal structures of the Sponge are preserved in the fossil state, but the true significance of these can only be properly understood by a consideration of the soft, vital portions of the organism as shown in existing Sponges. There is every reason to believe, from the substantial identity of the skeleton in recent and fossil forms, that the soft structures of the fossil forms were also essentially similar to those of the recent animals.

In all recent Sponges the free outer surface of the Sponge, as well as the interior lacunæ, and the canals leading from the surface to the ciliated chambers, are lined by a delicate membrane, consisting of a single layer of flattened, polygonal, nucleated cells forming an epithelium. This is regarded as proceeding from the ectoderm of the larva, and therefore styled the ectoderm[1] (Schulze). A similar layer of epithelial cells lines the canals leading from the ciliated chambers to the exterior, and this is regarded as of entodermal origin. The ciliated chambers or sacs are lined by cells of sub-cylindrical form, each furnished with a slight projecting collar and a slender flexible cilium or flagellum, also belonging to the entoderm. The surface epithelium is penetrated by numerous minute pores, either disposed singly or grouped together, which open into the lacunar spaces or into canals which convey the water into the interior of the Sponge, and these pores are usually surrounded by contractile fibres, by which they can be closed and opened. It is also penetrated by larger apertures, the vents, or oscules, which are the terminations of the canals conveying the water to the exterior, after it has passed through the ciliated chambers. These apertures may be either scattered over the surface of the Sponge, or grouped round a large central cavity, the cloaca, opening to the exterior.

The greater portion of the body-substance in living Sponges belongs to the mesoderm, and consists of a soft gelatinous, or, in some cases, cartilaginous groundmass of connective tissue, in which are nuclei, granular particles, contractile fibres, and various other forms of cells, possessing different functions. Some of these cells are amœboid, others spindly or stellate, whilst others are ova and sperm-sacs.

[1] "On the Structure and Arrangement of the Soft Parts in *Euplectella aspergillum*," 'Trans. Roy. Soc. Edinb.,' vol. xxix, p. 669, 1880.

The late discoveries of Mr. C. Stewart and of Dr. von Lendenfeld also clearly show that in many Sponges nerve-cells are present. The skeletal structures of the Sponge are also products of the mesoderm, and the siliceous and calcareous spicules probably all originate in cells, though their character has not yet been definitely ascertained.

The physiological characters of Sponges have not yet been thoroughly worked out. It has long been known that the water containing the food and respiratory supplies entered by the pores, and, after circulating through the incurrent canals and the ciliated chambers, found its way to the exterior by the excurrent canals and the vents or oscules, but it is not yet certain whether the food is ingested by the cells lining the incurrent canals as well as by those of the excurrent canals or merely by these latter. The flagellated cells of the ciliated chambers were formerly believed to ingest the food, but they are now regarded as performing respiratory and excretory functions as well as promoting the circulation of the water through the Sponge.

Form of Fossil Sponges.

In regard to their external form, fossil Sponges present the same extraordinary variety as living examples of the group. It frequently happens that even when all the structural characters of the Sponge have been obliterated, the form remains in the fossil state, and until recently this feature has been employed to a great extent in the definition of fossil species, though it is now known to be so variable, even in the limits of the same species, as to be of very subordinate value. There is no connection between the external form and the skeletal characters, for we meet with the same variety in all the groups of fossil Sponges, whether lithistids, hexactinellids, or calcisponges, nor can one particular form be said to be more especially abundant than another.

Fossil Sponges are present in the form of cups, vases, or platters, and transitional forms between these. Thus, a simple plate-like Sponge may in the process of growth become fan-shaped, and by the further infolding of the walls, and the anastomosing of their margins where they touch each other, it becomes cup- or vase-shaped, or the reverse process may take place, and a Sponge, which in its early stages may be vasiform with a funnel-shaped cloacal cavity, becomes expanded in the progress of its growth, so that the mature form is that of an expanded platter with a small central funnel. As examples of the platter-shaped forms may be cited species of the lithistid *Verruculina*, and calcisponges of the genera *Elasmostoma* and *Rhaphidonema*, whilst *Ventriculites cribrosus*, Phill., is typically vasiform, and *Ventriculites radiatus*, Mant., is expanded with a central funnel. Other

Sponges are sub-spherical or pyriform, as species of *Aulocopium*, *Melonella*, and *Siphonia*; club-shaped, as species of *Phymatella* and *Rhopalospongia;* cylindrical or sub-cylindrical, as in species of *Scytalia* and *Pachinion;* or dendritic, giving off branches from a main stem, as in *Thamnospongia clavellata*, Ben.; or dichotomously branching with partial anastomosis of the branches, as in *Doryderma dichotomum*, Ben. Again, the branches may be compact, or merely traversed by longitudinal canals, as in the series just named, or they may be hollow tubes as in *Sestrocladia furcatus*, Hinde. Some Sponges are nearly spherical, as *Astylospongia præmorsa*, Goldf., and *Plinthosella squamosa*, Zitt.; and others assume the form of mushrooms, as the lithistid *Seliscothon planus*, Phill., and species of the hexactinellid genus *Cœloptychium.* In other cases the growth of the Sponge is irregular, and the form indefinite, as in species of *Plocoscyphia.*

In compound or colonial Sponges, the simple individuals forming the colony are more frequently cylindrical tubes, which spring from the same base, and form the mass either by subdivision or by budding. These tubes are either independent of each other, save where they start from the parent stock, or they partially coalesce together during their growth, and are only separate near their distal ends. It is difficult to determine in many cases whether the entire mass is to be considered as an individual Sponge, or as a group of individual Sponges growing together in a colony. Thus, for example, in many species of *Peronella* the compound Sponge consists of cylindrical tubes growing parallel to, but separate from, each other, except at the point where their growth commences, and the Sponge is regarded as a colony of simple individuals. On the other hand, in *Elasmocœlia faringdonensis*, Mant., the cylindrical tubes are precisely similar in character to those of *Peronella*, and each probably has similar functions, but, instead of being separate, the walls are completely united together and enclosed in a common dermal membrane, and the entire mass is regarded as a simple Sponge, whereas strictly it is as much a colony of individuals as a compound example of *Peronella.*

In many fossil Sponges the body of the Sponge is supported on a cylindrical stem or peduncle of varying length and thickness, and frequently having a minute structure differing considerably from that of the body itself. This feature is more particularly shown in lithistid Sponges, and good examples occur in the genera *Chenendopora* and *Siphonia.* It is not so prominent a feature in fossil hexactinellids, though well marked in *Cœloptychium.* In general, fossil Sponges appear to have possessed flattened basal extensions, or elongated, branching, root-like appendages, for the purpose of anchoring themselves in the soft mud of the sea-bottom, or of attachment to other organisms or hard substances. These anchoring appendages take the form of horizontal or obliquely diverging extensions of the stem of the Sponge, or they may spring directly from the basal portion of the body of the Sponge in those cases in which no stem is developed. Such root-like

appendages are commonly present in fossil lithistids and hexactinellids, but in fossil calcisponges the attachment more generally occurs by means of a basal expansion. As more distinctive anchoring appendages may be mentioned the ropes or bundles of long spicular rods proceeding from the base of the Sponge, and penetrating into the bottom ooze, as in the hexactinellid genus *Hyalostelia* (Pl. VI, figs. 2, 3 *d*).

Though the majority of fossil Sponges appear to have been furnished with means of attachment, others were undoubtedly free in their mature condition, and seem to have merely rested on the sea-floor without being in any way definitely fixed. This is shown by the entire, evenly rounded, and sometimes concave form of the basal portion of the skeleton. Prof. Ferd. Roemer has noted that this free condition is a well-marked peculiarity in most of the Sponges from Palæozoic strata. It is well shown in *Astylospongia* (Pl. II, fig. 5), and *Aulocopium*; in the different genera of the family *Receptaculitidæ* (Pl. II, figs. 1, 2), in *Amphispongia oblonga*, Salt., (Pl. III, fig. 3) in *Phormosella ovata*, H. (Pl. III, fig. 2), and in *Dictyophyton Danbyi*, M'Coy sp. (Pl. II, fig. 4). It also occurs in some Cretaceous Sponges, as, for example, in the hexactinellid genus *Stauronema*, and in the lithistid, *Plinthosella squamosa*, Zitt.

As a general rule, fossil Sponges with thin walls are hexactinellids, but many forms in which the walls are apparently thick also belong to this same group. In this latter case, however, it will usually be found that the apparent thickness is really due to numerous closely arranged foldings of a simple thin wall. In lithistid Sponges, on the other hand, as already remarked by Zittel, the walls are thicker and of a more compact, firm, and stony character, so that they bear more general resemblance to the cœnenchymal tissue of Corals, than to that of normal Sponges. As regards the compact structures of the skeleton, fossil calcisponges resemble lithistids, but in general they can be readily distinguished from Sponges of this latter group, leaving on one side the different nature of their spicular skeletons, by their smaller dimensions and the continuous reticulation of the fibres on their outer surfaces. These distinguishing features of the outer form and general appearance in the different groups of fossil Sponges are frequently largely masked by their condition of preservation, but they will sometimes afford a clue to the real character of the Sponge, when its spicular structure has been destroyed.

In many fossil calcisponges the exterior or under surface is partially or entirely covered by a smooth, even, or corrugated membrane, resembling in general aspect the epitheca of Corals, whilst the upper surface is furrowed and uneven, and destitute of this dermal layer. A similar structure is occasionally present in lithistid and hexactinellid Sponges.

Size.

There is a great amount of variation in the dimensions of fossil Sponges, though not reaching to the extremes present in living forms. The smallest fossil examples at present known are calcisponges, of which two species have been described, *Blastinia pygmæa*, H., and *Peronella nana*, H., varying from 2·7 mm. to 5·2 mm. in length, and 3·5 mm. in width; or about the size of peas. On the other hand, cylindrical lithistid Sponges, belonging to *Stichophyma tumidum*, H., and *Doryderma Benetti*, H., reach an extreme length of 390 mm. (15½ inches), and a thickness of 125 mm. (5 inches). An open cup-shaped lithistid, *Kalpinella rugosa*, H., is 110 mm. (4½ inches) in height, and 230 mm. (9¼ inches) in extension at the summit. Fossil hexactinellids do not attain the same large size as the largest lithistids; an example of *Ventriculites cribrosus*, Phill. sp., is 240 mm. in length by 55 mm. in width at the summit, and an imperfect specimen of *Sporadoscinia capax* is 170 mm. in height by 168 in width at the summit. Fossil calcisponges are, as a rule, smaller than those of other groups, but exceptional examples of *Elasmostoma* and *Pharetrospongia* reach a length and width of 100 to 200 mm. (4 to 8 inches).

Canal-structures.

The canals in living Sponges form usually a complex system of anastomosing tubes, of varying degrees of fineness, lined by epithelial membrane. In fossil Sponges the canals consist of cylindrical channels bounded by the spicular tissues, in the same manner as those shown in macerated and dried specimens of recent horny and siliceous Sponges. In the fossil, as in the dried recent examples, all the finer canals have disappeared, and only the course of the larger can be made out in the skeleton. Further, in the fossil specimens the canals are not infrequently now infilled with the calcareous or siliceous rocky material in which the Sponge is embedded, and in some cases they are so filled with resistant silica that they appear as a solid network of fibres standing out on the surface of the Sponge. In many fossil Sponges, more particularly in those with a very open spicular skeleton, no distinctive canal-system can be discovered; and these forms are usually described as being without canals, but there can be no doubt that such Sponges in the living state possessed canals, the course of which, owing to the open character of the skeleton, is not shown. In other fossil Sponges, the walls bounding the larger canals consist of a distinct spicular membrane of a finer character than the ordinary skeletal tissues of the body.

In fossil Sponges, as in recent forms, there appears to be two distinct systems

of canals; one, the incurrent system, leading from the surface to the interior of the Sponge, and the other or excurrent passing from the interior and opening out at the surface or into the cloaca. The incurrent canals (Fig. 1, *in.*) are, as a rule, much smaller than the excurrent; they commence at the surface by small circular apertures which are distributed irregularly, and extend into the sponge-wall either

FIG. 1.—*Siphonia tulipa,* Zittel. A vertical median section through the Sponge, showing the cloaca (*cl.*), the fine incurrent canals (*in.*), and the excurrent canals (*ex.*) opening into the cloaca. From the Upper Greensand at Warminster, Wilts. Natural size.

at right angles or obliquely to the surface. The apertures of these incurrent canals have usually been named "pores," but, as[1] Dr. Holl has already remarked, they are not analogous to the pores in living Sponges, which are minute apertures in the soft surface membrane of the Sponge, and could not, therefore, be represented in the skeleton. The apertures in the fossil Sponge rather correspond to the openings of the incurrent canals in the recent forms, and may be either termed incurrent-canal apertures, or, as Sollas names them, ostia. The excurrent canals (*ex.*, Fig. 1) are much more prominent than the incurrent, and less numerous. They open out by circular apertures, either at irregular intervals on the upper surface of the Sponge, or they converge to the infundibuliform or tubular cavity in the centre of the Sponge, which is known as the cloaca or cloacal tube (*cl.*, Fig. 1). Sometimes the excurrent canals terminate at the surface in papilliform projections, with the aperture at the summit. Their apertures are known as oscules or vents, but the former term has sometimes also been employed for the cloaca itself.

[1] "Notes on Fossil Sponges," 'Geol. Mag.,' 1872, vol. ix, p. 346.

In many fossil Sponges the cloaca is altogether absent, or it is merely represented by a slight shallow depression at the summit of the Sponge. Thus, in extended platter or fan-shaped Sponges no cloaca is present, and the excurrent canals usually terminate on the upper or inner surface of the sponge-wall; though occasionally they appear on the under or outer surface, and in some instances even on both surfaces of the wall. In other Sponges of cylindrical or conical form, in which the cloacal cavity is not present, the excurrent canals generally extend longitudinally throughout the length of the Sponge, and the vents open at the rounded or truncate summit. As a rule, the difference in the size of the vents and of the ostia or incurrent-canal apertures, is sufficient to determine their respective characters; but in some Sponges the difference is too slight to enable them to be separately distinguished.

In no instance, so far as I am aware, is the presence of ciliated chambers indicated in the skeleton of any fossil Sponge, owing no doubt to their minute dimensions.

Canal-system in Fossil Monactinellid and Tetractinellid Sponges.—So few of these Sponges are preserved in an entire form in the fossil state that very little has been ascertained respecting their canal-structures. In the fossil genera of *Pachastrella*, *Opetionella*, and *Scoliorhaphis*, there are only irregular interspaces between the spicular tissues, and no definite canals; radial canals are present in *Climacospongia;* and in fossil *Cliona* the circulation appears to have been similar to that of the recent species of the genus, and the vents opened at the surface through the circular apertures made in the shell inhabited by the Sponge.

Canal-system of Fossil Lithistid Sponges.—In this group Zittel[1] enumerates six different modifications of the water-circulation.

(1) That in which a special canal-system is altogether wanting. This, of course, means that the canal-system must have been disposed in the irregular interspaces of the skeletal mesh, since there are no indications of it in the skeleton itself. Sponges in which this condition occurs have no cloaca, and no special vents; as examples may be mentioned some species of *Platychonia* and *Holodictyon.*

(2) The sponge-wall is penetrated more or less deeply by branching canals of varying size, which open at the surface, the larger being the vents of the excurrent canals, and the smaller the apertures of the incurrent canals. The vents usually open on the upper surface of the wall, and the incurrent-canal apertures on the under surface. The canal-apertures in some instances are equal in size on both surfaces of the walls, and the vents cannot then be distinguished from the incurrent canal-apertures. Sometimes the canals enter the wall obliquely. In certain instances the excurrent canals are nearly horizontal, and have a stellate arrangement round the vent. Sponges with this system are platter- or open cup-shaped,

[1] 'Studien,' ii Abtheil., p. 75.

and without cloaca. Typical examples belong to *Verruculina*, *Chenendopora*, and *Kalpinella*.

(3) In this system a well-marked cylindrical or funnel-shaped cloaca is present. The excurrent canals can be traced from near the outer surface to the cloacal cavity, in which the vents are disposed either in rows or irregularly; the canals are either simple or branched, and nearly horizontal in direction. The incurrent canals begin near the cloacal surface and radiate outwards, opening at the surface of the sponge-wall. The Sponges are usually cylindrical or clavate. This system is present in the genera *Cylindrophyma* and *Phymatella*.

(4) This modification closely approximates to the preceding. It occurs in sub-spherical or cylindrical Sponges with deep and narrow cloacal tubes. The incurrent canals are numerous, fine, and unbranched; they extend either horizontally or obliquely from the outer surface to the interior of the wall. In some instances the excurrent canals open into the cloacal tube as in the preceding modification, and they also appear as open furrows radiating down the sponge-wall from the margins of the cloacal aperture. This modification occurs in *Scytalia* and *Pachinion*.

(5) In this the incurrent system is represented by numerous delicate canals extending from the outer surface of the Sponge in an arched direction towards the centre, whilst the excurrent system consists of relative large canals which extend from the basal portion of the Sponge in a generally vertical direction parallel to its contour, and open into the cloaca. These excurrent canals are frequently shown as open furrows on the outer surface of the Sponge, extending from the margins of the cloaca to the lower portion of the body. In the living condition they were covered over by the soft dermal tissues, as well as by the skeletal dermal layer of spicules, which is now rarely preserved *in situ*. These superficial excurrent canals, now represented as open furrows, would, in the further growth of the Sponge, become enclosed by the skeletal mesh, and then resemble the present internal canals, which have all, in their turn, been formed just beneath the dermal surface of the Sponge.

This canal-system is typically developed in *Siphonia* (fig. 1), *Melonella*, *Aulocopium*, and *Astylospongia*; and it is also present in those lithistid Sponges of conical, cylindrical, or branching form, in which no cloaca is developed, and the vertical excurrent canals extend the entire length of the Sponge, and open at its summit, either grouped in bundles or apart from each other. In the branching Sponges the vertical canals extend the entire length of the branches, and open at their distal ends. In these Sponges the finer incurrent canals are either horizontal or oblique in their course, similar to those in Sponges where a cloaca is present. Examples of this type belong to *Jereica*, *Stichophyma*, *Doryderma*, and *Jerea*.

(6) In this last division the massive wall of the Sponge is divided up into

delicate vertical laminæ, with narrow, simple, or branched intervening fissures so as to give the Sponge a radiate appearance like that of a Coral. The canals follow the course of these fissures, thus running radially from the outer surface in a generally horizontal direction to the centre of the Sponge. Their apertures are disposed in the fissures over the lateral surface in vertical rows. The vents are situated on the upper or inner surface of the sponge-wall. In this division are included the Jurassic genera *Cnemidiastrum* and *Corallidium* and the Cretaceous *Seliscothon.*

Canal-system of Fossil Hexactinellids.—As the mode of growth in the majority of fossil hexactinellids consists of a thin wall of spicular meshwork, offering a largely extended free surface to the surrounding medium, the canal-system is not of so complex a character as in lithistid Sponges, in which the skeleton is much thicker. In general there is a system of short, blind canals penetrating the thin wall on both sides at right angles to the surface, and extending nearly through it. In addition to these, in some cases a system of pseudo-canals or inter-canals is produced, by various infoldings in the walls themselves, and by the development of a supplementary dermal layer of spicular tissue lining the outer surface of the Sponge and the cloacal cavity, and thus forming a sac-like cavity in which the folds of the wall are contained. The following are some of the modifications of the canal-system in this group.

(1) In which special canals are not present, or are not indicated in the spicular meshwork of the skeleton. In this case the sponge-wall consists of a simple extended layer of spicular mesh, in which only the ordinary quadrate interspaces between the spicules are present. An outer modified spicular dermal layer may be present with regularly disposed apertures, but these are not connected with canals. The genus *Callodictyon* is a typical example.

(2) In which there are special canals extending quite through the sponge-wall. In general appearance the wall of the Sponge differs but little from that of the preceding, but on close examination it is seen that the tubular canals which penetrate quite through it, at right angles to the surface, are not mere ordinary openings in the spicular mesh, but they are definitely bounded by a modified arrangement of the spicular rays of the mesh. A dermal layer is present. This modification is clearly shown in the genus *Aphrocallistes.*

(3) In which the canals terminate blindly in the sponge-wall. In this case the small tubular canals are present on both surfaces of the sponge-wall, and communicate with the exterior by small circular apertures. They reach nearly through to the opposite surface of the wall and terminate blindly. They are usually disposed in alternate rows on the respective surfaces, so that in the interior of the wall the canals are side by side. It seems probable that these blind canals belong to the excurrent system and that the water entering through the smaller apertures of the dermal

layer reached the ciliated chambers, and then passed to the exterior through them. This canal-system is typically seen in the genera *Craticularia*, *Guettardia*, *Coscinopora*, and *Stauronema*.

(4) In which an inter-canal system is developed. In addition to the tubular blind canals in the proper wall of the Sponge, a secondary system of lacunar spaces and anastomosing channels is produced by the infolding and convolutions of the walls. As a well-known example may be mentioned the genus *Ventriculites*. In Sponges of this genus the spicular membrane of the wall is disposed in a series of closely-arranged vertical folds, and the outer surface exhibits vertical ridges and furrows in which are rows of elongated apertures. These apertures are connected with the interspaces between the folds of the wall, as may be seen in a transverse section through the Sponge, and therefore belong to the inter-canal system. The interior surface of the Sponge, next the cloacal cavity, or on the upper surface where no cloaca is present, is usually lined with a dermal membrane with regularly arranged circular apertures, which likewise connect inwardly with the interspaces between the folds of the wall. The genus *Cephalites* has a disposition of the inter-canal system similar to that in *Ventriculites*.

In *Camerospongia* and *Cystispongia* the laminated walls of the Sponge are still further folded, and contained as in a sac by an outer spicular membrane, in which there may be a funnel-shaped cloaca, or merely several wide apertures leading directly into the interior of the sac. In the genus *Plocoscyphia* the folds of the wall are very complex, and they generally anastomose so as to form an intricate system of wide tubes and lacunar spaces which belong to the inter-canal system. The walls themselves usually possess a distinctive perforated dermal layer, and they are penetrated on both sides by blind canals, like the walls of those Sponges in which no folds occur. In the genus *Cœloptychium* the folded walls of the Sponge are contained as in a case by a rigid spicular, perforated dermal layer, which freely admits the flow of water into the internal cavity; and on the ridges of the under surface of the Sponge, formed by the folding of the wall, there are rows of oval or elongated apertures, which may be compared to vents.

Canal-system of Fossil Calcisponges.—In a single genus, *Protosycon*, there appears to be a similar arrangement of the canals as in Haeckel's family *Sycones*. In this form the walls are penetrated by horizontal tubes or radiate canals which open into the tubular cloaca. In some calcisponges no distinctive canal-system is shown in the disposition of the spicular fibres of the skeleton, and the canals in the living animal must have followed the interspaces between the fibres. Thus in some species of *Peronella*, in which the Sponge is cylindrical, with an axial cloacal tube, no traces of canals appear in the skeleton, and the canals, which most probably in the living Sponge opened into the cloaca, entered through the ordinary interspaces of the skeletal fibres. Also in *Pharetrospongia* and *Pachytilodia*, in which the walls

are frequently of considerable thickness, and the interspaces between the skeletal fibres are comparatively large, no distinctive canals are present. In other calcisponges a system of branching canals extends from the interior of the wall, either to the cloacal cavity or to the general upper surface of the Sponge, terminating in single vents or in small groups of vents. In some forms also open canals radiate from the margins of the cloacal cavity down the sides of the Sponge. Examples of this structure are shown in *Sestrostomella*, *Stellispongia*, and *Lymnorea*. In the genera *Elasmostoma* and *Rhaphidonema*, one surface of the sponge-wall is covered with a minutely perforate dermal layer, whilst the opposite surface has larger scattered vents, which are connected with branching canals. In *Tremacystia* the wall, consisting of but a single layer of spicular fibre, is perforated by circular apertures which lead into hollow chambers, and these latter are connected together by a cribriform axial tube, which opens at the summit of the Sponge and probably represents the cloaca.

Chemical Constitution and Mode of Preservation of Fossil Sponges.

Only those Sponges are definitely known as fossil in which the skeleton was originally either of siliceous or calcareous composition. Sponges with keratose or horny skeletons have not with certainty been shown to exist in the fossil state. The changes which have taken place in the mineral structure of both siliceous and calcareous Sponges during fossilization, have, in many cases, so completely altered their original nature that it requires careful study and considerable experience to determine the groups to which they belong. It is owing to these changes not having been properly understood that so much misconception has arisen respecting the real nature of these organisms, and the supposed radical differences between them and existing forms; and it is therefore a matter of the first importance in the study of fossil Sponges to consider somewhat in detail the changes by which their primary structures have been so largely modified.

1. *Siliceous Sponges; the nature of the Silica, and the changes in it during fossilization.*—The silica forming the skeletal spicules and spicular mesh of *recent* Sponges, is in the amorphous or colloid condition, beautifully clear, like a perfect glass, and quite negative in polarized light, between crossed Nicols. It is also soluble in heated caustic potash. It is very rare to find the silica of fossil spicules retaining the same brilliant glassy appearance and structure as in the recent forms; and, so far as I am aware, this perfect condition of preservation is only found in detached spicules and fragments of spicular mesh, which have been preserved in a matrix of fossil diatomaceous or radiolarian earth of Tertiary age. Spicules in this condi-

tion are present in a diatomaceous rock of the pre-Miocene age from Oamaru, New Zealand, and in marls from St. Peter, Hungary.

In fossil siliceous Sponges the silica may be either (*a*) amorphous or in the colloid state; (*b*) chalcedonic or cryptocrystalline, or (*c*) crystalline. It may also be replaced by glauconite, or other mineral silicate; or dissolved so as to leave empty negative casts of the spicular skeleton in moulds of limestone, chalk, or silica; or the moulds may be infilled and the silica replaced by crystalline calcite, iron-pyrites, or iron peroxide. The siliceous skeleton may, further, be entirely dissolved without leaving any mould or trace of its presence, whilst the form of the Sponge is retained, and the canals infilled with a solid mass of silica. The Sponges may still consist of silica, but the minute structure of the skeleton may be partially or entirely obliterated, and the silica re-deposited as chalcedony. In this state the Sponges in the Chalk are frequently enclosed in an outer casing of solid flint.

(*a*) The silica amorphous. In this case the silica of the Sponge skeleton is in a colloid condition, like that of recent Sponges, and it presents the same reaction to heated caustic potash, and it is likewise negative to polarized light, but it has lost the brilliant glassy aspect present in the siliceous skeleton of recent Sponges. The skeleton of Sponges in this condition has a porcellanous, milky-white appearance by reflected light; and in transmitted light, when mounted in Canada balsam, it is nearly transparent, and the silica appears to be in the form of minute granular particles with a pinkish reflection, and not infrequently of minute spherules or discs. If mounted in glycerine the spicules become so transparent that nothing more than faint outlines of their forms can be seen. As a rule the surface of the spicules, in which the silica retains the original amorphous condition, is smooth and even, and the axial canals are usually wider and therefore more distinct than in recent forms. These axial canals appear in many instances to be now filled with chalcedonic or crystalline silica, and they frequently remain after the more soluble silica of the spicular walls has been dissolved away. Sponges in which the silica remains amorphous are comparatively rare, and in this country I have only seen examples from the Upper Greensand of Wiltshire; but they are common in glauconitic marls of Senonian age in North Germany. Detached spicules in this condition are present in considerable numbers in the interior of masses of chert from the Upper Greensand of Wilts, and in nodules in the so-called malm or firestone rock, of the same geological horizon, at Merstham, Surrey.

(*b*) The silica is cryptocrystalline or (*c*) crystalline. The spicular skeleton, in which the silica is in either of these states, has by reflected light either a pure snowy white tint, or a dull glassy appearance, not unlike that of ground glass. When mounted in Canada balsam, and viewed by transmitted light, the spicules become so transparent that but little more than their contours can be distinguished, but in glycerine their forms stand out very distinctly. In polarized light they

exhibit between crossed Nicols the same shades of colour as chalcedony and quartz, and in many instances in the same spicule there is a gradual passage from the chalcedonic to the crystalline state of the silica. The outer surface of the spicular skeleton in this condition of the silica is rarely smooth, but generally much eroded, and apparently covered over with minute pitted depressions, which give the skeleton a very ragged appearance under the microscope, and the delicate extensions of the spicular rays appear as if largely worn away by erosion. The axial canals also of the spicules can rarely be detected, probably owing to the fact of their having been infilled with silica of the same optical character as the wall of the spicule, and therefore indistinguishable from it. In the majority of siliceous Sponges in which the skeleton has been preserved the silica is now in the condition of chalcedony. In some, however, the change has reached a further stage, and it is altogether crystalline. The experiments of Mr. Hannay[1] on the siliceous fossilization of the Sponge-spicules from the Lower-Carboniferous Rocks of Scotland show that the change from the amorphous silica of recent Sponges to the cryptocrystalline and crystalline silica of the fossil forms is mainly owing to the loss of chemically-combined water, which causes crystallization to set in.

The alteration in the spicular skeleton of the Sponges just referred to is mainly limited to the condition of the silica of which it is composed, and the detailed form of the skeletal mesh and spicules is retained as in existing Sponges; but in many fossil Sponges, notably in those from the Upper Chalk, the skeleton is still of silica, but the skeletal tissues have lost their distinctive form, and the place of the regular spicular meshwork is taken by shapeless fibrous masses of chalcedonic or crystalline silica, which present an appearance as if the original silica of the skeleton had been fused. This alteration is well exemplified in the Sponges from the Upper Chalk of Flamborough, Yorkshire, which, when freed by acid from the chalky matrix, retain for the most part their complete outer form and the fibrous character of the skeleton, but the delicate spicules of which the fibres were originally composed have altogether disappeared, and the fibres are now of shapeless granular particles of silica.

In other cases, as in many of the Sponges from the Upper Chalk of Wilts and elsewhere which have been enclosed in flint, the spicular structure of the outer surface of the Sponge is occasionally still preserved, and consists of crystalline silica of a snowy-white tint, but the structure of the interior is usually changed to a mass of botryoidal or porous chalcedonic silica, in which even the course of the canals has been obliterated. These masses form, as it were, cores within the flints, and are frequently entirely free from the outer casing of flint. Not infrequently between the Sponge and the flint there is a very fine, white, siliceous powder, oftentimes containing detached spicules.

[1] 'Mem. Lit. and Phil. Soc. Manchester,' vol. vi, S. 3, p. 234.

Siliceous Skeleton dissolved, leaving empty casts.—The spicular skeleton of many fossil Sponges, after being enclosed in the rock, has been dissolved, leaving hollow impressions of its minute structure in the matrix. The outer form in these Sponges is usually retained by the matrix, which may be either of chalcedonic or crystalline silica, limestone, or chalk. The impressions of the minute spicular structures are usually most distinct when the matrix is of silica, which now forms a solid mass, in which the minute hollow moulds of the skeleton are contained; but even when the matrix is of such a soft material as the Upper Chalk of the South of England, the hollow casts of the spicular skeleton are retained very perfectly, and even such minute structural details as the hollow lantern-nodes of the hexactinellid spicules are clearly shown. Not only entire Sponges occur as empty casts, but even the moulds of detached spicules are also present in the bands of chert and siliceous rock of the Upper Greensand, and frequently to such an extent that the rock is porous and light on account of the numerous minute cavities in it formed by the dissolution of the spicules. In some of these minute fusiform hollows there is an axial filiform siliceous rod, which is the solid cast of the spicular canal, remaining after the walls of the spicule itself have been dissolved away.

Another modification of the process by which the cast of the skeletal structures is retained after the solution of the skeleton itself, is shown in some hexactinellid Sponges from the Upper Greensand, in which the spicular mesh is invested with a delicate pellicle of silica, and then subsequently dissolved, leaving, as it were, an outer shell of its form. A similar alteration has also been recorded by Manzoni[1] in hexactinellid Sponges from the Miocene strata of Bologna, but in these the spicular mesh is in part retained after its investment by the siliceous pellicle.

Examples of the removal, by solution, of the spicular skeleton of siliceous Sponges occur in almost every geological horizon in which Sponges are present. Thus in the Silurian genera *Astylospongia* and *Hindia* the skeleton in many of the specimens forms negative casts in a siliceous matrix; in many of the hexactinellid Sponges from the Upper Chalk of the South of England the hollow moulds of the skeleton are preserved in the soft chalky matrix, and a similar dissolution of the skeleton has also taken place in the siliceous Tertiary Sponges of Bologna.

These undoubted instances of the solution and removal of the silica of Sponge skeletons completely negative the idea, held to within a comparatively recent date, that silica is sufficiently stable to resist the ordinary influences of fossilization. It may be accepted as proved that silica in the colloid state, in which it occurs in the skeleton of recent siliceous Sponges, and also in the original condition of fossil Sponges, is extremely liable to chemical changes, and that it is only when in the condition of chalcedony or crystalline that it can be regarded as stable. The changes in the siliceous skeletons of fossil Sponges, mentioned above, show the

[1] 'Spugne silicee del Miocene medio,' p. 17, pl. 3, figs. 15, 16, 1882.

tendency of the silica to pass from the unstable colloid to the stable chalcedonic and crystalline condition. Under favorable conditions this chemical change has taken place without destroying the form of the spicular skeleton, but in other circumstances the colloid silica of the skeleton has been wholly dissolved away and redeposited, usually in the chalcedonic condition, so as to form solid beds of chert and bands of nodular flints. Some recent experiments of M. Thoulet[1] on existing siliceous Sponges show that the silica is readily susceptible to the solvent influences of the chemical ingredients of salt water, and fossil Sponges have been exposed to similar influences, during the interval of fossilization, from the action of water, charged with chemical substances, percolating through the rocks.

Siliceous Skeleton replaced by Calcite and Glauconite.—The form of the Sponge is usually retained in such cases, but instead of the original silica the skeleton now consists of transparent crystalline calcite. As a rule, the Sponges in which this replacement occurs are embedded in a calcareous matrix, and by the action of dilute acid both the matrix and the replaced skeleton are equally dissolved. The replacement does not seem to have been produced by the molecular substitution of the calcite for the silica, but it is probable that the calcite has been deposited from solution into the hollow moulds left by the removal of the original silica. Where the spicular mesh is of an open character, or in the case of large spicules, the original form can be recognised in the replaced structures; but when the spicular mesh is minute and closely arranged, as in rhizomorine lithistids, the calcitic replacement is indefinite and confused, and the distinctive form of the original spicules can no longer be made out. It is thus very difficult to determine the original character of Sponges in this condition. On the other hand, in cases where the calcite has infilled the moulds formed in a matrix of chalcedonic silica, the replaced skeleton presents all the details of the original siliceous skeleton, with such even and clearly defined outlines that it has been mistaken for the original substance of the skeleton, and the Sponge has been described as calcareous. Typical examples of this replacement are shown in specimens of *Astylospongia* from the Silurian strata of Gothland and of *Hindia* from nearly the same horizon in New Brunswick.

This replacement of the siliceous skeleton by crystalline calcite oftentimes takes place in the Sponges of definite horizons in particular localities, whilst at other horizons but little removed the Sponges retain their siliceous structures. Thus, for example, in certain Sponge-beds in the Grey or Lower Chalk near Dover and Folkestone the siliceous structure of the Sponges has been entirely replaced by calcite, whilst the Sponges in the underlying chloritic marls of the same locality and in the Isle of Wight retain the silica. Similar instances are

[1] 'Bulletin de la Soc. minéralogique de France,' T. vii, 1884, p. 147.

recorded by Zittel[1] in the Sponge-beds of the Upper Jura of Switzerland, Wurtemberg, Bavaria, and Poland. In certain localities the entire siliceous skeleton is replaced by calcite, whilst in others the original silica remains, though in the condition of chalcedony. On the other hand, many instances occur in which the calcitic replacement is only partial, even in the same Sponge, and by treatment with acid the calcareous portions are dissolved, whilst fragmentary portions of the siliceous structure remain behind.

The replacement of silica by glauconite is of much less frequent occurrence, but the change has taken place in detached spicules in the Sponge-beds of the Upper Greensand. The glauconite in these specimens appears first to have infilled the axial canal of the spicule, and afterwards to have been deposited gradually, in proportion as the silica of the wall of the spicule has been removed. In other instances the siliceous spicules are replaced by a mineral of a greenish-white tint, apparently allied to glauconite, and nearly entirely transparent when viewed under the microscope in Canada balsam. This replacement is also frequently accompanied by a very peculiar distortion and contraction of the spicules. It occurs in spicules preserved in cavities of Upper-Greensand chert at Ventnor and at Warminster in Wiltshire.

Siliceous Skeleton replaced by Peroxide of Iron and Iron-pyrites.—This latter mineral but seldom takes the place of the silica, but the former is of frequent occurrence; and Sponges thus replaced are found in strata from the Silurian upwards, and they are more particularly abundant in the Upper Chalk of the South of England. The peroxide occurs as a rusty, reddish brown, often powdery and incoherent, material. As a general rule the finer structures of the skeleton are not preserved in this material, and they are usually so confused as to be unrecognisable. Rarely, however, as in the case of some of the *Ventriculites* from the Upper Chalk, so carefully worked out by Toulmin Smith, the peroxide is sufficiently firm to allow of the chalky matrix being removed, and the skeletal structure stands out by itself, but it is nevertheless very delicate and perishable. It is somewhat unfortunate that the majority of the siliceous Sponges in the Upper Chalk of the South of England, in which the matrix is the Chalk itself, should have had their skeletons replaced by this incoherent peroxide, since, though their entire forms are retained, and their canal-systems can be made out, the minute characters of their spicular tissues cannot be determined with precision. Not infrequently also the peroxide has replaced the silica in Sponges enveloped in a matrix of solid flint; and the replacement is particularly well shown in specimens of *Ventriculites* and *Plocoscyphia*, whose delicate convolute or labyrinthine walls appear in section on the surface of fractured flint like narrow reddish bands. In some cases these bands show the minute spicular structure, but more frequently it is altogether indistinct and unrecognisable.

[1] 'Studien über fossile Spongien,' i Abth., p. 13, 1877.

Siliceous Sponges in Flint and Chert.—Mention has already been made of the fact that some of these Sponges occur as solid cores, enclosed either partially or completely in a casing of flint, and also that in some the structures in flint are replaced by iron peroxide.

In other instances the outer form of the Sponge is shown by the flint, but all traces both of the canal and spicular structures have disappeared entirely, and the interior of the Sponge is a compact mass of homogeneous flint. Very frequently, however, whilst the spicular structure of the Sponge has been completely obliterated in the interior of the flint, the canal-system is very clearly and definitely shown in a solid form, owing to the canals having been filled with flint of a different tint to that of the matrix. Such Sponges are common in the Chalk of the vicinity of Brighton, and they are generally known under the term *Choanites*, though most of them really belong to the genus *Siphonia*. In many of the Silurian Sponges from the Baltic basin and from Canada also, which are now compact masses of cherty silica, the minute spicular structure has been destroyed, whilst the canals are shown in the same manner as in those in the Upper-Chalk flints. In some cases also only the lower portion of a Sponge is enclosed in flint, whilst its upper portion has been changed into iron peroxide, and is enclosed in a matrix of soft chalk. The flint-enclosed basal portion of these Sponges very frequently occurs in gravels formed from chalk flints.

Not only are *entire* Sponges thus enclosed in various ways in flints, but also detached spicules are preserved in great numbers in the cavities of Upper Chalk flints, and in irregular hollows in chert, from the Carboniferous and Upper Greensand strata. They are usually loosely mingled in a fine siliceous powder with other organic remains. In some instances the silica of these spicules is amorphous, but more frequently it is either chalcedonic or crystalline. Detached spicules also occur in arenaceous strata, as in the Lower Greensand of Haslemere, Surrey, and in the Upper Greensand of Devonshire and in the Eocene Tertiary near Brussels. In some beds they occur in what may be regarded as an unaltered condition, that is, loosely intermingled in the sandy strata; in others some of the spicules appear to have been dissolved, and the sandy matrix and the spicules are partially cemented together by silica to form pumice-like, porous accretionary masses of cherty rock; whilst in a further stage the spicules are for the most part dissolved, and beds of massive chert result, in which only hollow casts and shadowy outlines of the original spicules are occasionally visible.

Though the larger skeletal spicules of siliceous Sponges are present in great numbers, and in a fairly perfect state of preservation, the smaller or so-called flesh-spicules are very seldom met with in the fossil state. A few of them have been figured by Zittel from the Senonian strata of Westphalia, and they also occur in Tertiary deposits, mingled with diatoms and radiolarians, from Hungary and

New Zealand, but it seems probable that in older strata they have not resisted the destructive influences of fossilization.

2. *Calcisponges, their Mineral Structure, and the changes in it during fossilization.*—The carbonate of lime forming the spicules of existing calcisponges is beautifully clear and transparent in appearance and is doubly refracting in polarized light. It has been stated to be very unstable, so that the spicules are readily liable to dissolution, but there is reason to believe that this is not usually the case. As a general rule, the mineral character of fossil calcisponges has been less altered by fossilization than that of fossil siliceous Sponges, though owing to the much smaller dimensions of the spicules and their close arrangement in the skeletal fibres, their distinctive forms have been largely obliterated, even when the fibres have retained their form and mineral structure intact. Detached spicules of calcisponges have lately been discovered in beds of Tertiary age at St. Erth in Cornwall, and at Goes in Holland, retaining the same clear and transparent appearance as recent spicules; their structure in every respect appears to have remained unaffected by the fossilization, and they could not have been distinguished from the spicules of existing forms. Again, in some of the calcisponges from Cretaceous strata, near Havre, the spicules, though now so closely interwoven together in the fibre that they can only be examined in thin microscopic sections, retain the same clear, transparent form of the calcite and the same sharp definite outlines as in recent forms. The smaller spicules in these Sponges are, in many instances, equally as well preserved as the larger, and they show a greater capacity of resistance to the destructive effects of fossilization than siliceous spicules of similar dimensions.

In general the spicular fibres of fossil calcisponges retain their original structure of carbonate of lime, though the form of the component spicules has to a large extent disappeared, and the fibres are now either of crystalline grains of calcite or show a finely radiate prismatic structure. This alteration in the fibres is by no means uniform, for in the same Sponge the forms of the component spicules may be fairly well shown in one portion, whilst in another the fibres only exhibit an aggregation of mineral grains. Thus, in the calcisponges from the Upper Chalk of the South of England the fibres have an ivory-white, smooth, glistening appearance, and they retain their outer form very perfectly, but when examined in thin sections under the microscope they are seen to be mostly of granular or fibrous crystalline calcite, in which the outlines of the spicules have disappeared or are shown very imperfectly. In the calcisponges from the Upper Greensand of Wiltshire the fibres are of a soft, earthy, greyish-white calcite, and in some cases they break up into their component spicules. In these the calcite is, in part at least, in a granular state, their outlines are either smooth or exhibit an eroded aspect, due to some extent to the cementation of grains of the matrix to their surfaces.

In the calcisponges from the Lower Greensand of Faringdon, Berkshire, the fibres are of a greyish tint, and the crystallization has largely obliterated the spicular structure, and in many instances the fibres are invested with an outer coating of calcite crystals. In the Jurassic calcisponges the outer form of the Sponge and the fibres are well preserved, but their minute spicular components have been, to a large extent, destroyed by the secondary crystallization of the calcite, and only occasionally are the larger spicules faintly shown.

It is worthy of notice that, in striking contrast to many siliceous Sponges, in which the skeleton has been preserved in a negative form, as hollow moulds in an enclosing matrix, no undoubted calcisponge has, to my knowledge, been met with in this condition, but in all cases the fibres are present, either as calcite, or, more rarely, replaced by crystalline silica.

Calcisponges replaced by Silica.—This replacement is of infrequent occurrence, and it usually takes place in strata in which Corals and other calcareous organisms as well as the Sponges have become siliceous. Calcisponges thus silicified can be obtained quite free from matrix by treatment with acid; their fibres are then of a snowy-white tint, with rough and uneven surfaces, and all traces of the spicular structure have disappeared.

An exceptional mode of preservation is shown in some examples of *Pharetrospongia* from the so-called Cambridge Greensand and from the Upper Chalk of Kent. The Sponges are usually calcareous throughout, but in some instances a partial replacement of the fibres by silica has taken place. When treated with acid the interior portion of the fibres, being calcareous, is dissolved, but a thin exterior pellicle of silica remains, in which the form of the minute acerate spicules can be seen. In the Upper Chalk examples, those which are embedded in the chalky matrix have their fibres entirely calcareous, and they are completely dissolved in acid, whilst in the specimens embedded in flint the outer layer of the fibres is replaced so as to form a thin pellicle of silica, the same as in the Cambridge Greensand specimens. This different mineral condition of the fibres, according as they are enclosed in chalk or flint, may be observed not infrequently in the same specimen, part of which is in the flint, and has the silicified surface-pellicle enveloping the fibre, whilst another portion is in the chalk, and the fibres are throughout calcareous. There can be no doubt that the thin surface-film of silica on the fibres of the flint-enclosed examples of *Pharetrospongia* is owing to the replacement of the original calcite by the silica, such as usually takes place in calcareous organisms enclosed in flints. It has been contended that this genus was originally siliceous, and that the calcareous fibres result from the replacement of the original silica by calcite. That, however, the forms are really calcisponges is further shown by the fact that no other undoubted siliceous Sponge in the Upper Chalk presents the same mineral structure and appearance as these examples of *Pharetrospongia*.

Modifications in Fossil Sponges resulting from their Spicular Structures.—Hitherto we have considered the changes produced in fossil Sponges by the chemical alteration of their skeletal constituents, but there are other modifications arising from the way in which their skeletal elements are built up, which have an important bearing on the preservation of the Sponge in the fossil state. Sponges in which the skeletal elements are free from each other, and merely held in position by the soft, fleshy structures of the living organism, cannot, except under very favorable circumstances, be preserved entire in the fossil state, but their skeletal spicules, on the death of the animal, and the decay of the soft tissues, become detached and indiscriminately mingled together in the ooze of the sea-bottom. On the other hand, Sponges in which the skeletal spicules are closely and intimately connected, or organically united together, retain their entire forms, other conditions being favorable, in the fossil state.

Thus the component spicules in monactinellid and tetractinellid Sponges are either only loosely embedded in the soft tissues, or they form anastomosing fibres enclosed in perishable spongin, and as a result entire Sponges belonging to these groups are very rare in the fossil state. As exceptional examples may be mentioned the Carboniferous genus *Haplistion*, Young, and from the Cretaceous strata of Germany *Opetionella*, Zitt., and *Scoliorhaphis*, Zitt., whilst some forms of *Ophiraphidites*, and *Pachastrella* occur in the Upper Chalk in this country. In these cases the free spicules are very thickly disposed amongst each other in the body of the Sponge, and the Sponges appear to have been undisturbed whilst they were gradually covered with sediment. In some instances the spicules have been subsequently cemented together by a secondary deposition of silica. In contrast to the rare occurrence of entire Sponges of these groups as fossil, is the abundance of their detached spicules, which, intermingled together, form extensive beds, like those described by Dunikowski[1] from the Lower Lias of Schafberg in the Tyrol, by the writer[2] in the Lower and Upper Greensands in this country, and by Rutot[3] in the Eocene of Belgium. They are also similarly abundant in the Upper Chalk. These detached spicules evidently belong to various genera and species of Sponges, but their entire forms have been wholly destroyed.

In lithistid Sponges, in which the component spicules are more or less intimately united together by the interlacing of their branching extremities, the entire form of the Sponge is usually preserved, though in those belonging to the Megamorina family, in which the union of the spicules is of a simpler character, the Sponges have, to a great extent, been disintegrated, and their component spicules occur detached in great numbers in the Lower and Upper Greensands and in the

[1] 'Denkschr. der Kais. Akad. der Wiss. Wien,' 1882.

[2] 'Phil. Trans.,' Pt. ii, 1885.

[3] 'Ann. de la Soc. Malacol. de Belgique,' Tome ix, 1874.

Chalk. The manner in which these detached spicules are dispersed in the matrix, and their perfect forms, show that this disintegration took place shortly after the death of the Sponge, and before it was covered with sediment, and also that they have not been transported far from the locality in which the Sponges existed. The dispersion of the spicules, when they are not united together into a connected skeleton, is very strikingly shown in the case of those forming the dermal layer of lithistid Sponges, which, unlike those of the body of the Sponge, are free and merely held in position by the penetration of their pin-like shafts into the Sponge. Though there is every reason to suppose that fossil lithistids, like recent ones, were uniformly provided with a dermal layer of differentiated spicules, this is very rarely now retained, but the detached spicules themselves are not infrequently met with dispersed in the matrix.

In the dictyonine group of fossil hexactinellid Sponges, the spicules are completely amalgamated together, and consequently these Sponges retain their entire form even though their walls are frequently of a thin and delicate character. In the lyssakine group, on the other hand, in which the spicules are free from each other, examples of entire Sponges are very rare, but the detached spicules are very abundant in the Lower Carboniferous of Ayrshire and Yorkshire, and also in the Upper Chalk.

Fossil calcisponges as a rule retain their entire forms, and detached spicules of these Sponges are rarely met with. This preservation of the entire form is the more surprising since the component spicules of their skeletal fibres are not organically attached together, and their habitat in shallower water would have exposed them to more disturbed conditions. The spicules in these fibres appear, however, to have been very closely and intimately arranged, and to this may be due the fact that they have not been disintegrated. On the theory of Dunikowski[1] that the fibres of fossil Pharetrones are not original, but produced by fossilization, it is difficult to understand how they could have retained their entire forms, since in all other cases, as we have seen, the effects of fossilization are rather to break up and disintegrate the spicular structures than to consolidate them.

Skeletal Structures of Fossil Sponges.

The skeleton of all known fossil Sponges is built up of small[2] mineral particles, usually of microscopic dimensions, and of very varying forms, which are combined

[1] 'Die Pharetronen: Palaeontographica,' Bd. xxix, p. 283, 1883.

[2] Sponges with skeletons of horny fibres have not yet been definitely shown to exist as fossil. Though various forms have by some authors been referred to horny Sponges, there is no satisfactory evidence that they belong to this group. The *Dysidea antiqua* of Carter, 'Annals and Mag. Nat. Hist.,' 1878, vol. i, p. 139, described as a horny Sponge, is a siliceous monactinellid, which had been previously named by Young and Young, *Haplistion Armstrongi*, 'Annals, &c.,' 1877, vol. xx, p. 428.

together in different ways, so as either to form a continuous framework or loose open fibres, which serve as a support to the soft fleshy portions of the Sponge. These mineral particles are termed spicules, a word used in a general sense to indicate the individual element or particle of the skeleton, whatever may be its form. The spicules of fossil Sponges, like those of recent ones, are composed either of silica or of carbonate of lime. In all essential features they resemble the spicules of existing Sponges, and it may be assumed that like these latter they have been formed in cells in the mesoderm of the Sponge. Spicules consist of an outer wall of concentric layers, enclosing in most, if not in all cases, a delicate longitudinal axial canal, which extends either partially or entirely the length of the spicule, and into each of its main arms or rays. This axial canal is usually much wider in fossil spicules than in recent forms; in the living condition the canal appears to have been filled with protoplasm, but in the fossil state it is usually occupied by a mineral substance of the same general character as the spicular wall. If the infilling material has the same optical characters as the wall of the spicule, the canal can no longer be distinguished, and the spicule appears solid throughout; but not unfrequently the infilling substance of the canal is more resistent than the spicular wall, and remains even when this latter has been dissolved away. Between each of the concentric layers of the spicular wall there appears to have been originally a thin film of organic substance. The structural layers are but rarely seen in fossil spicules; they can, however, be occasionally distinguished in the rod-like spicules of *Hyalostelia* (Pl. VI, figs. 2 *a*, 2 *c*, 3 *f*).

Two different kinds of spicules are usually recognised in recent Sponges, skeletal-spicules and flesh-spicules, and both kinds are present in the fossil forms, though the latter are of very subordinate importance in the fossil state, owing to their rare occurrence. The skeletal-spicules form the main body of the Sponge and are usually of much larger dimensions than the flesh-spicules. These latter, on the other hand, exhibit a much greater variety of form than the skeletal-spicules; they are not attached together, but merely held in position by the soft tissue of the Sponge, and consequently are not often found in their natural position in fossil Sponges.

The two chief considerations in the study of fossil Sponges are, first, the character of the individual spicules, and next, the mode in which they are combined to form the skeleton. The skeletal-spicules of fossil Sponges have been arranged in groups based on the number and disposition of their axes or rays. Taking first those of siliceous Sponges, the following typical divisions may be enumerated:

1. Monactinellid spicules, or those in which a single axis is present.

2. Tetractinellid spicules, in which there are four rays or axes, which radiate from a common centre in the same direction as the axes of a regular, three-sided pyramid.

3. Lithistid spicules, with four or more rays proceeding from a common centre, or irregularly branching forms.

4. Hexactinellid spicules, with six rays, forming three axes which cross each other at right angles.

5. Octactinellid spicules, with eight rays, six of which are in one plane and the other two form an axis at right angles to the plane.

6. Heteractinellid or polyaxile spicules, with a variable number of rays extending from a common centre.

Various modifications of the typical forms of these different groups are of frequent occurrence. These may arise either by an increase in the number of rays by furcation, or by a suppression of one or more of them. Thus, in tetractinellid spicules subdivision takes place oftentimes in one or more of the principal rays, and the same thing rarely also occurs in hexactinellid spicules ; in these, however, suppression of one or more of the normal six rays frequently happens. Again, the spicular rays may become modified so as to form an entire or lobate disc, as in the dermal spicules of some lithistid Sponges.

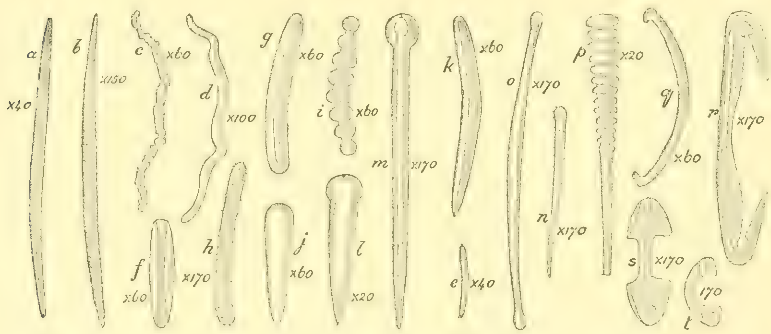

Fig. 2.—Different forms of fossil siliceous monactinellid spicules from Upper Greensand, Chalk, and Tertiary strata. (*a*) Curved, fusiform, acerate spicule, showing the axial canal open at both ends. (*b*) Acerate spicule with minute constrictions. (*c*) Vermiculate nodose acerate from *Scoliorhaphis cerebriformis*, Zitt. (*d*) Vermiculate acerate, smooth. (*e*) Acerate, acutely pointed. (*f*) Acerate, probably immature, having the axial canal open throughout. (*g*) Simple curved cylinder, with axial canal completely enclosed. (*h*) Cylinder, microspined. (*i*) Moniliform cylinder, *Monilites Haldonensis*, Carter. (*j*) Conical spicule. (*k*) Smooth, curved, acuate spicule. (*l*) Pin-shaped or spinulate. (*m*) Spinulate, showing the axial canal. (*n*) Acuate spicule, microspined. (*o*) Tibiella, fusiform, with inflated extremities. (*p*) Moniliform acuate. (*q*) Bihamate, *Esperites Haldonensis*, Carter. (*r*) Bihamate or clasp-hook (flesh-spicule). (*s*) Bispatulate (flesh-spicule). (*t*) Equianchorate (flesh-spicule).

1. Monactinellid Spicules.—The typical character of the spicules of this group is a simple unbranched axial canal, which generally extends throughout the length

of the spicule and is either open or enclosed by the spicular wall at one or both ends. In the case of many acerate spicules, the canal opens to the exterior at both ends of the spicule (Fig. 2, *a*); in cylindrical spicules it is usually enclosed at both ends by the spicular wall (Fig. 2, *g*), whilst in acuate and spinulate spicules the canal is enclosed at the truncate or inflated head and opens at the apex of the spicule (Fig. 2, *m*). In some forms, which are regarded by Zittel as immature spicules, the canal remains open throughout its length (Fig. 2, *f*). In moniliform spicules like those shown in Fig. 2, *i*, *p*, the canal does not follow the inflations of the spicule, but continues of an even width throughout.

There is very great variation in the form and size of monactinellid spicules; some of the commoner types are represented in the accompanying Fig. 2. The most abundant form is the acerate, generally thickest in the central portion and gradually tapering to the ends (Fig. 2, *a*, *b*). It may be either straight, curved, or vermiculate (Fig. 2, *c*, *d*), either pointed or obtusely blunted; smooth or partially or entirely microspined. Numerous gradations exist between the acerate and the cylindrical forms, which likewise may be straight or curved (Fig. 2, *g*), smooth or more or less spined (Fig. 2, *h*). In acuate spicules the head is truncate or evenly rounded (Fig. 2, *k*, *n*), and the spicule gradually tapers to a pointed extremity, whilst when it tapers abruptly the spicule is conical (Fig. 2, *j*). From these there is a gradual transition to the spinulate or pin-shaped spicules (Fig. 2, *l*, *m*), in which the head of the spicule is variously enlarged and may be either sub-spherical or conical in form. In another form, which has been named tibiella, the spicule is cylindrical or fusiform with inflated ends (Fig. 2, *o*). In some acuate and cylindrical forms the spicule is moniliform and consists of a series of inflated rings with intervening furrows (Fig. 2, *i*, *p*).

There is a still greater range of variation in the form of the minute flesh-spicules associated with the monactinellid skeletal-spicules; some are simply bihamate (Fig. 2, *q*), in others the ends are sharply incurved like those of a clasp-hook (Fig. 2, *r*), and there is a trenchant inner edge; in a third form both ends of the spicule are expanded so that it may be termed bi-spatulate (Fig. 2, *s*), whilst in the very common "anchor" flesh-spicules there are from two to three in-curved grapnel-like hooks at both ends of the spicule, which may be either equal (Fig. 2, *t*) or unequal in size.

2. Tetractinellid Spicules.—The typical spicule of this group has four equal, straight, pointed rays extending from a common centre, so as to form the four axes of a regular three-sided pyramid, the angle between each of the rays thus being 120°. A longitudinal canal is present in each ray, extending from the centre to the termination of the ray (Fig. 3, *a*). The modifications of this ground-form are exceedingly numerous. Thus the rays of the spicule may be unequal in length, and one or all of them may be furcate, as in some of the spicules of

Pachastrella primæva (Fig. 3, *l*). Again, one of the rays may be reduced to a slight knob, or may not be developed at all, and the spicule becomes tripodal in form (Fig. 3, *b*), and can then scarcely be distinguished from the three-rayed spicules of calcisponges, more particularly when the tripodal elevation is reduced, so that the three rays are nearly in a horizontal plane. An important differentiation is shown in the so-termed trifid or zone-spicules, in which one of the rays is very much elongated and enlarged in proportion to the other three. This elongate ray is known as the shaft of the spicule, it is straight or slightly curved, and usually

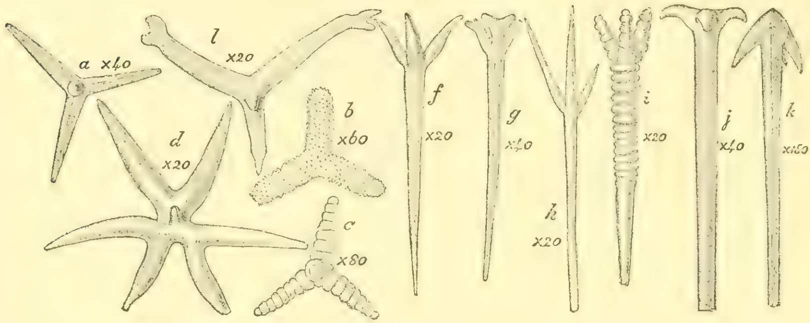

FIG. 3.—Various forms of fossil siliceous tetractinellid spicules from Upper Greensand, Chalk, and Tertiary strata. (*a*) Regular tetractinellid or four-rayed spicule, *Pachastrella Haldonensis*, Carter. (*b*) Microspined spicule in which only three rays are developed. (*c*) Regular four-rayed spicule, moniliform, *Pachastrella quadriradiata*, Carter. (*d*) Compound trifid spicule, the shaft abbreviated, and the head-rays furcate and extended horizontally. (*l*) Four-rayed spicule of *Pachastrella primæva*, Zitt., in which two rays are incipiently furcate. (*f*) Simple trifid or zone-spicule of *Geodites*, sp. (*g*) Compound trifid or zone-spicule of *Geodites planus*, in which the head-rays are furcate. (*h*) Simple trifid or zone-spicule of *Geodites*, sp. (*i*) Simple trifid or zone-spicule, moniliform, *Geodites Wrightii*. (*j*) Trifid or zone-spicule of *Stelletta inclusa*, Hinde, in which the head-rays are recurved. (*k*) Trifid spicule in which the head-rays are sharply recurved so as to become anchor-shaped.

tapers to an acute point (Fig. 3, *f*). At the head or distal end of the shaft the three other rays project at various angles. These head-rays vary very much in different spicules. They may be straight or curved, conical, acutely pointed, or club-shaped. In many cases, one or more of these rays divide and become furcate (Fig. 3, *g*), and the canal similarly divides, and an arm extends into each ray. The head-rays diverge from the summit of the shaft either in a forward direction (Fig. 3, *h*), obliquely, horizontally, or they are more or less recurved (Fig. 3, *j*, *k*). Both rays and shaft are

usually smooth, but in some instances they are moniliform as in *Geodites Wrightii*, Hinde (Fig. 3, *i*). These trifid spicules are frequently radiately disposed, so that the head-rays are extended near the outer surface of the Sponge, and hence they have been termed zone-spicules. They are abundant in the existing *Geodia*, Lam., and allied genera, and in the fossil *Geodites*, Carter.

In another form, the spicule is modified in a reverse way to that of the trifid spicules just described, for the ray corresponding to the elongated shaft is reduced to a short blunt process, whilst the head-rays are greatly developed. They are usually furcate, and the rays extend in a generally horizontal direction, forming a right angle with the diminutive shaft (Fig. 3, *d*). These spicules, equally with those in which the shaft is elongated, are disposed at or near the outer surface of the Sponge. They have been referred to the genus *Stellettites*, Carter.

In some of the detached spicules of this group, from Carboniferous strata, only two head-rays have been developed, as in *Geodites deformis* (Pl. V, figs. 4 *d*, *g*), and similar spicules also occur in the Upper Greensand.

3. Lithistid Spicules.—There is such great diversity of form in the spicules of lithistid Sponges that no single example can be quoted as typical of the group as a whole. The skeletal-spicules forming the body of the Sponge exhibit the greatest amount of variation, whilst in many instances the spicules of the dermal layer are extremely regular in form, and present a striking contrast to the skeletal-spicules even of the same Sponge. In what is regarded as the highest developed group of lithistids, the skeletal-spicules consist of four rays, disposed in the same manner as those of tetractinellid spicules, and with an axial canal in each ray; whilst in other divisions the skeletal-spicules give off irregularly secondary rays from a main stem, in which there is a single unbranched canal. But it frequently happens that the dermal spicules of Sponges with this peculiar form of skeletal-spicule are distinctly tetractinellid in type, thus indicating a certain amount of relationship between these divisions. Professor v. Zittel has divided lithistid Sponges into the four families of the *Rhizomorina*, *Megamorina*, *Anomocladina*, and *Tetracladina*, according to the respective characters of their skeletal-spicules.

(*a*) *Rhizomorina.*—In this family of lithistids the skeletal-spicules usually consist of a slender, curved main axis, from which minute, twig-like branches and spinous processes are given off irregularly. The extremities of the branches, where they come in contact with adjoining spicules, are furnished with minute, flattened facets. A simple axial canal can sometimes be seen extending either partially or throughout the length of the main axis (Fig. 4, *b*), but there are no diverticles from it into the branches. Typical spicules of this character are present in *Seliscothon Mantelli*, Goldfuss sp. (Fig. 4, *a*, *b*). In another form there is a short, relatively stout, main axis, not infrequently smooth, with diverging branches and spines from both ends, which are likewise facetted at their extremities. This type is well shown in the

skeletal-spicules of *Cnemidiastrum Hoheneggeri*, Zitt. (Fig. 4, *c*), from Upper Jurassic strata at Cracow, and in species of *Aulocopium*, from Silurian strata in Gothland (Fig. 4, *d*). This latter genus has indeed been placed by Zittel in the Tetracladina family, but in the character of its skeletal-spicules it appears to me more nearly to resemble *Cnemidiastrum* than any tetracladine genus. Rarely, also, in some of the Sponges of this family, spicules occur in which three subequal spinous rays radiate from a common centre, thus approximating in form to the tetracladine spicules. Zittel[1] has figured a spicule of this form from *Hyalotragos patella*, Goldf. sp.

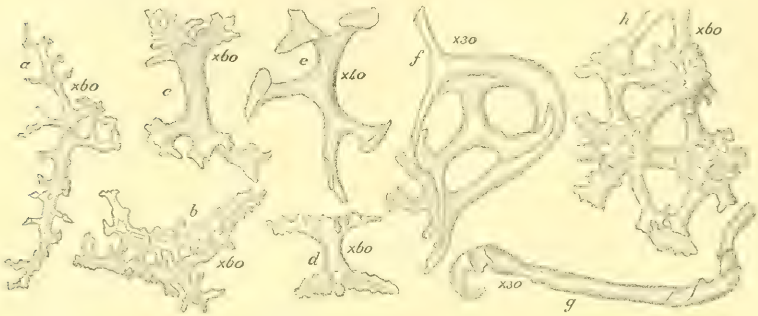

FIG. 4.—Various forms of fossil lithistid spicules belonging to the families of the Rhizomorina, Megamorina, and Anomocladina. (*a*) Branching, spinous, skeletal-spicule of rhizomorine lithistid, *Seliscothon Mantelli*, Goldf. sp. (*b*) Two skeletal-spicules of the same Sponge, showing their mode of union with each other. (*c*) Skeletal-spicule of the rhizomorine Sponge, *Cnemidiastrum Hoheneggeri*, Zitt., from the Upper Jura of Cracow. (*d*) Skeletal-spicule of the rhizomorine Sponge *Aulocopium*, sp. from the Silurian of Gothland. (*e*) Skeletal-spicule of a megamorine Sponge, *Doryderma*, sp. from the Senonian strata of Coesfeld, Westphalia. (*f*) Skeletal-spicules of *Doryderma*, showing their mode of union with each other. (*g*) Skeletal-spicule of the megamorine Sponge, *Carterella*, sp. (*h*) Portion of the skeletal mesh of the Anomocladina Sponge, *Astylospongia*, sp. from the Silurian of Gothland, showing the spicules and their mode of union with each other.

(*b*) *Megamorina*—The skeletal-spicules of this family consist of a straight, or, more frequently, variously curved, elongated main axis, which may either be simple, or may give off irregular branches in different directions (Fig. 4, *e*, *f*, *g*). The terminal ends of the main axis and of the branches either form tapering blunted processes, or more usually expand into flat or concave, spoon-shaped surfaces. Both the tapering extensions and the concave expansions may be

[1] 'Studien ueber fossile Spongien,' ii, Taf. 3, fig. 4.

present in the same spicule (Fig. 4, *c*). The spicules of this family are relatively large, and their surfaces smooth. As a general rule, only a simple canal is present, and this only partially, in the main axis of the spicule, but in the great majority of the spicules the canal is not distinguishable in the fossil condition. In the genera *Isorhaphinia*, Zitt., *Carterella*, Zitt., and *Nematinion*, Hinde, the spicules are threadlike and variously notched. In *Carterella* the simple spicule has slender, curved, and twisted extremities (Fig. 4, *g*), whilst in *Isorhaphinia* the spicule has slightly tumid terminations. The greatest diversity of form is shown in the spicules of *Megalithista*, Zitt., *Dorydermа*, Zitt., and *Heterostinia*, Zitt., which are curved so variously, and give off lateral and terminal branches in such an irregular manner that it is difficult to find any two spicules closely alike (Fig. 4, *e*, *f*).

(*c*) *Anomocladina.*—The elementary skeleton-spicule of this family of lithistids consists of a thickened, rounded, or compressed central node, from which a variable number of rays (from three to nine) radiate in different directions. The rays are usually smooth, simple, or occasionally furcate, and they terminate in expanded surfaces with even or digitate margins (Fig. 5, *a*). In the genus *Cylindrophyma*,

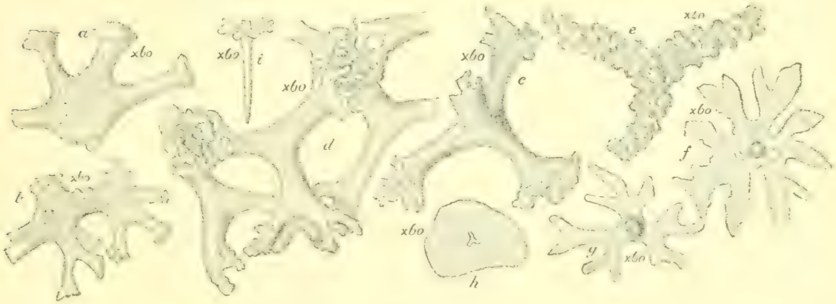

FIG. 5.—Various forms of fossil skeletal- and dermal-spicules of lithistid Sponges. (*a*) Elementary spicule of Anomocladina lithistid, *Mastosia Neocomiensis,* Hinde, from the Upper Greensand of Warminster, Wilts. (*b*) Paired or twin spicule of Anomocladina lithistid, *Cylindrophyma milleporata*, Goldf., sp. (*c*) Skeletal-spicule of Tetracladina lithistid, *Callopegma acaule,* Zitt. (*d*) Skeletal-spicules of *Callopegma Schlœnbachii*, Zitt., showing their mode of union with each other. (*e*) Skeletal-spicule of tetracladine lithistid, *Plinthosella squamosa,* Zitt. (*f*) Dermal spicule of lithistid, showing the canals. (*g*) Another dermal spicule, showing the rudimentary shaft. (*h*) Dermal spicule of lithistid, in which no shaft is developed, but traces of the canals remain. (*i*) Dermal spicule of lithistid with furcate head-rays.

Zitt., many of the elementary spicules are of a twin-like character, consisting of two distinct nodes united by a short cylindrical axis (Fig. 5, *b*). From each of

these nodes are given off simple and furcate rays with expanded ends as in the spicules with single separate nodes. In the normal elementary spicules of this family no definite canals have been observed, and even in the spicules of the sole existing representative, *Vetulina stalactites*, Os. Schmidt, canals do not appear to be present; at all events they are not mentioned or figured by Sollas[1] in his recent paper on this species. In the twin spicules of *Cylindrophyma*, however, as first pointed out by Dr. Linck,[2] there is a well-defined simple axial canal in the short axis connecting the two nodes of the spicule, and this canal can occasionally be traced into the central portion of one or other of the nodes, thus proving that the twin nodes and the connecting axis form a single elementary spicule. The canal, however, does not give out branches into the rays of either of the twin nodes. In many of the spicules of *Cylindrophyma Steinmanni*,[3] Linck, there is a gradual diminution in the size of the nodes and the rays proceeding from them, which become also more spinous, and they then resemble spicules of the Rhizomorina family, and can scarcely be distinguished from those of *Cnemidiastrum Hoheneggeri*, for example (Fig. 4, *c*). On the other hand, the rays given off from the nodes of Anomocladina spicules are very similar to the branches given off from the main axis of Megamorina spicules, and the principal differences in the spicules of these two families consist in the fact that the spicular rays or arms in this latter proceed irregularly from an elongated axis, whilst in the former they proceed from a central node.

Professor Zittel[4] has lately defined the elementary spicule of the Anomocladina family as consisting of simple, straight, or curved rods more or less branched at both ends, and forming nodes by the union of the branched ends of proximate spicules. Judging, however, from the characters of the spicules of the existing *Vetulina stalactites*, O. Sch., in which the central node, and the rays proceeding from it, evidently form a single structure, as figured by O. Schmidt[5] and by Sollas,[6] and from the further fact that in the fossil examples of *Cylindrophyma*, the spicules produced by the disintegration of the skeleton likewise consist of nodes or centra with radiating rays, the evidence seems to be strongly in favour of the theory that these bodies are really the elementary spicules, and not, as suggested by Professor Zittel, compound bodies formed by the union of several simple rod-like spicules.

(*d*) *Tetracladina*. In this family the skeletal-spicules are four-rayed; the rays or arms diverging from a common, non-inflated centre, at an angle of 120° from each other; they are either smooth (Fig. 5, *c*), or covered with small tubercles (Fig. 5, *e*). Near their extremities the rays divide into two or more branches,

[1] 'Proc. Royal Irish Academy,' 2 ser., vol. iv, No. 4, p. 486.

[2] 'Neues Jahrb., &c.,' 1883, ii Band, 1ster Heft, p. 59.

[3] Ibid.

[4] 'Neues Jahrb., &c.,' 1884, Band ii, p. 75.

[5] 'Die Spongien des Meerbusen von Mexico,' p. 19, pl. ii, fig. 9.

[6] 'Proc. Royal Irish Academy,' 2 ser., vol. iv, p. 486, pl. iv.

and these again subdivide into minute twig-like extensions, which are beset with tubercular nodes and swellings. The spicular rays are usually subequal in length; in each there is an axial canal, which in some cases subdivides, and extends into the main divisions of the ray, but cannot be traced into the minute extensions. Typical spicules of this family are present in the genera *Siphonia*, Park., *Phymatella*, Zitt., and the existing *Discodermia*, Bocage. In *Plinthosella*, Zitt., *Spongodiscus*, Zitt., and *Phymaplectia*, Hinde, the skeletal-spicules are less regularly developed, the rays are often very unequal in length, and diverge from each other at unequal angles, the branches terminate obtusely, and the entire spicule is thickly covered with rounded tubercles (Fig. 5, *e*). Some of the skeletal-spicules of *Rhagadinia* have one of the four rays reduced to a rounded knob, and the other rays are partially annulated.

In many lithistid Sponges the spicules forming the stem and root-like appendages of the Sponge differ from those of the body-portion, the modification generally resulting in an elongation of the rays.

Dermal Spicules of Lithistids.—In addition to the skeletal-spicules, on the characters of which the four families above mentioned are based, there are also in most, if not all, lithistid Sponges, modified spicules forming the outer surface of the Sponge, which in many instances depart widely in form from the skeletal-spicules. Some of these are distinctly tetractinellid, and are precisely similar in form to the trifid spicules with horizontally-expanded head-rays, which have already been referred to (Fig. 3, *d*). Thus in the genus *Doryderma*, with its large, irregular skeletal-spicules, the dermal spicules are minute trifid spicules with short, simple, or furcate head-rays. The dermal spicules in some Rhizomorina Sponges are of the same general character as those of the skeletal forms, but of much smaller proportions, and with more closely arranged branches. In others, as in *Pachinion*, for example, these are mingled with trifid spicules with horizontally-expanded head-rays. These latter are also present in the tetractinellid genus *Callopegma*, as well as in other Sponges of the same family.

In other more specially modified dermal spicules, the primary head-rays of the trifid spicules become flattened out horizontally, and either divide and subdivide so as to form a filigreed expansion (Fig. 5, *f*), or they are united into a circular or lobate disc, in which the individual rays altogether disappear, though the relations of the spicule are still shown by the presence of three minute canals in its centre, indicating its origin from a simple trifid spicule (Fig. 5, *h*). In the filigreed forms the canals only extend to the first or second subdivision of the rays (Fig. 5, *f*). In these dermal spicules there is a minute central ray or shaft, which extends at right angles to the expanded head. The dermal spicules in the genus *Plinthosella* are minute, delicate, oval, lath-shaped or irregular laminæ, in which neither canals nor vertical shafts are developed.

4. Hexactinellid Spicules.—The typical spicule of this group has six equal rays radiating from a common centre, at right angles to each other, thus with three equal axes. Modifications of the type form occur through the unequal development of one or more of the individual rays (Fig. 6, *b*), which may be either extended or reduced, or even aborted altogether. Thus spicules frequently occur in which one ray is absent, so that a nail-shaped form results, with four rays in one plane, and the unpaired ray at right angles to it (Fig. 6, *c*). In other cases,

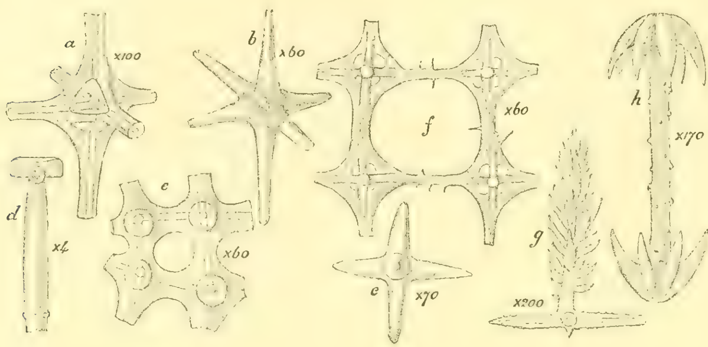

Fig. 6.—Different forms of fossil hexactinellid spicules and fragments of spicular mesh. (*a*) Spicule with lantern or octahedral node, showing the extension and union of the canals of the different rays in the centre of the node. (*b*) Simple detached spicule with rays of unequal length and slightly inflated compact node, *Hyalostelia fusiformis*, Hinde. (*c*) Detached nail-shaped spicule in which only five rays are present. (*d*) Spicule of *Receptaculites occidentalis*, Salt. (*e*) A fragment of the skeletal mesh of *Sestrodictyon convolutum*, showing the compact nodes and the apparent continuity of the canals between the nodes. (*f*) A fragment of the skeletal mesh of *Cœloptychium agaricoides*, Goldf., showing the lantern or octahedral nodes. (*g*) Plumose flesh-spicule. (*h*) Amphidisc flesh-spicule.

the vertical ray of the spicule is reduced to a rounded stump, as in some of the spicules of *Hyalostelia Smithii* (Pl. VI, figs. 1, 1, *a*). By the reduction of one axis the spicule becomes cruciform, as in *Protospongia* (Pl. I, figs. 1, *a*, 2, *a*). The reduction of the number of rays may even proceed so far as to leave a single elongated rod or fusiform axis, not to be distinguished externally from a spicule of the monactinellid type, but its real character is shown by the occasional slight development, in one portion of its length, of the transverse axial canals. As a general rule the spicular rays are simple and smooth (Fig. 6, *b*), but in some cases they bifurcate as in *Spiractinella* (Pl. VIII, figs. 1, 1 *c*), and this subdivision may be carried to

such an extent that the spicule appears stellate (Pl. VIII, figs. 1 *g*, 1 *h*). The rays are not infrequently more or less covered with minute spines or even moniliform. In the abnormal family of the *Receptaculitidæ*, the distal or external ray of the spicules is modified into a horizontally extended polygonal plate (Pl. IV, fig. 2), immediately beneath which are the four transverse rays (Pl. IV, fig. 2, *d*), whilst the proximal ray may be either greatly reduced, or normally tapering and pointed, or connected with an internal plate as in the genus *Receptaculites* itself.

In the spicules which serve for anchoring the Sponge to the sea-bottom, one ray is extremely elongated, reaching to a length of several inches, and at its distal extremity the other four rays are developed in the form of small recurved hooks (Pl. VI, figs. 2, *e*—*k*).

The junction of the rays at the central node in hexactinellid spicules may be formed by their simple union, or there may be a sub-spherical inflation, or from each ray there are given off near the central node short processes or balks, which pass obliquely to the proximate rays and form the outlines of a regular octahedron (Fig. 6, *a*, *f*). The rays, in greatly diminished thickness, serving merely as sheaths to the axial canals, are continued into the centre of this hollow octahedron, where they unite together. This peculiar modification of the spicular node was first noticed by Toulmin Smith in the Ventriculites from the Upper Chalk; it occurs also in the Jurassic genus *Pachyteichisma*, Zitt., and in many other fossil genera, and also in the recent *Myliusia*, Gray. Such nodes are termed octahedral or lantern, whilst the ordinary nodes are known as simple or compact.

In all complete hexactinellid spicules there is an axial canal in each ray, and the six branches unite together in the centre, both of the spicules with simple, and those with octahedral nodes. The presence of these canals serves to indicate individual spicules, even where a subsequent deposition of silica has completely masked the form of the spicule by merging it in a common extended membrane, as in the dermal layer of many Sponges of this group.

In addition to the skeletal-spicules, the so-called flesh-spicules are largely developed in recent hexactinellid Sponges, but, as already mentioned, their extreme rarity in the fossil state renders them only of subordinate interest to the palæontologist. They are usually of far smaller proportions than the skeletal-spicules, and exhibit a great variety of forms, which, however, in the majority of cases, can be recognised as modifications of the typical six-rayed spicule of the skeleton.

Two characteristic flesh-spicules recently discovered in pre-Miocene strata in New Zealand are shown in Fig. 6. In one (*g*) known as "plumose" or "pinulus," the four transverse rays are relatively small, whilst the fifth ray is unusually elongated and is thickly covered with upward-projecting spinous processes. In the other (*h*) or amphidisc spicule, a cylindrical rod has, at both ends, an umbrella-

shaped disc with several incurved rays. The derivation of this form from the normal hexactinellids is not apparent; it has been suggested by Schultze, however, that the incurved rays are only secondary processes of the nature of spines.

5. Octactinellid Spicules.—In typical spicules eight rays are present, six of which radiate in a horizontal plane from a common, slightly expanded centre at equal angles from each other, whilst the other two rays form a vertical axis (Pl. IV, figs. 8, *a—c*). This normal type is not, however, of such frequent occurrence as the modification, in which the rays forming the vertical axis are either reduced to small blunt knobs or altogether absent (Pl. I, figs. 7, *a*, *b*, *c*). In a single instance an abnormal spicule occurs in which only three of the horizontal rays are developed (Pl. I, fig. 7, *d*). The rays of these spicules are uniformly simple; the horizontal ones appear originally to have been equal in length, and they usually terminate obtusely. In weathered examples, open furrows are exposed on the surface of the rays, indicating the presence of canals. These spicules have been recognised in only a single genus, *Astræospongia*, F. Roem. By Ferdinand Roemer[1] the spicules were regarded as only normally possessing six rays, but Zittel[2] pointed out the presence of a vertical axis in addition to the horizontal rays. By this latter author, however, *Astræospongia* has been placed with the Lyssakine hexactinellids, but the number and disposition of the spicular rays differ so markedly from those of hexactinellid spicules that it is difficult to understand how they can have been derived from the hexactinellid type, and it seems preferable to regard them as belonging to a distinct sub-order.

6. Heteractinellid Spicules.—The above name is proposed for skeletal-spicules with a variable number of rays, ranging from six to thirty, extending from a common centre at different angles. In one genus, *Tholiasterella*, the spicules possess from six to nine rays, projecting nearly horizontally from a central disc, and a single ray extending at right angles from the centre of the disc. The rays may be equal or unequal in length, usually simple, tapering, and blunted, and with numerous projecting warts on their upper surfaces (Pl. VII, figs. 1, *c—g*, 2, *a—d*). In the genus *Asteractinella*, one form of skeletal-spicule has from eight to twenty rays radiating in different directions from a common centre. One of these rays is usually longer and more prominent than the others, which are unequal in size (Fig. 7, *a*); in another form of spicule there are as many as thirty rays, the greater number of which are disposed side by side and partially amalgamated, so as to form a nearly horizontal disc; on the under surface of this there are three or four rays diverging at various angles (Pl. VIII, figs. 3, *e*, *f*). Owing to the large size and thickness of the rays, it has not been practicable to determine the character of the axial canals. These spicules appear to fundamentally differ from the pre-

[1] 'Lethæa Pal.,' 1 Th., p. 314, 1880.

[2] 'Studien ueber foss. Spongien,' i, p. 59, 1877.

ceding types, and as there are no traces of their derivation from any of them it is necessary to place them in a distinct group.

There are also some other forms of fossil multiaxial siliceous spicules, most of which, if not all, belong to the dermal layer of various Sponges, and differ very widely from the skeletal-spicules of the body of the Sponges to which they belong. Of these the most common are the kidney-shaped or sub-spherical forms which build the outer crust of *Geodia*. These have been supposed by Oscar Schmidt to consist of a radial agglomeration of minute uniaxial spicules (Fig. 7, *b*, *c*). Others are the so-called stellate (Fig. 7, *f*,) and globo-stellate spicules (Fig. 7, *d*, *e*), in which a variable number of conical rays project either from a central point or from a rounded nucleus. Another widely-distributed spicule has the form of a delicate

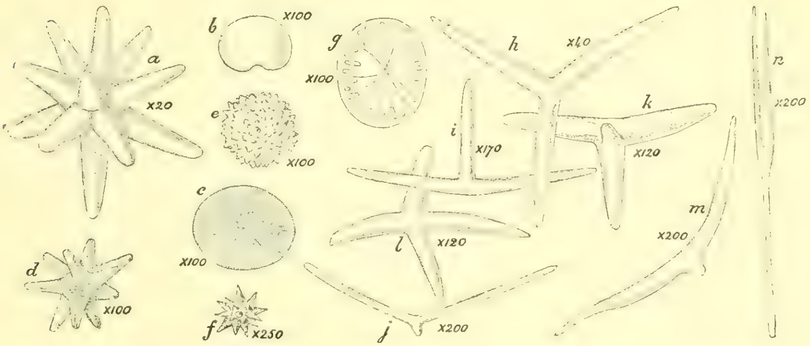

FIG. 7.—Different forms of fossil siliceous heteractinellid and multiaxial spicules and also spicules of fossil calcisponges. (*a*) Spicule of *Asteractinella expansa*, with twelve unequal rays proceeding from a common centre. (*b*) Kidney-shaped spicule of the dermal layer of *Geodia*. (*c*) Another dermal spicule of *Geodia*, showing its composition of apparent spicular rods. (*d*) Globostellate spicule in which there are traces of canals in each of the rays. (*e*) Globate spicule with a surface covered by minute spines. (*f*) Stellate spicule, probably of the dermal layer of a tetractinellid Sponge. (*g*) Thin elliptical disc with canals radiating from the centre; probably a dermal spicule, named *Stellettites callodiscus*, Carter. (*h*) A three-rayed equiangular and equiradiate spicule of fossil calcisponge. (*i*) A three-rayed sagittate spicule, with two equal, paired rays, and one ray, the basal, shorter than the other two. (*j*, *m*) Three-rayed spicules, with the basal ray only slightly developed; from the fibre of *Tremacystia D'Orbignyi*, Hinde. (*k*) Four-rayed sagittate spicule with blunted apical ray, from the same Sponge. (*l*) A four-rayed spicule, showing the apical ray. (*n*) Three rayed (tuning-fork) spicule, in which the paired rays are nearly parallel with each other.

elliptical disc, bordered by minute flask-shaped cavities, and a series of canals radiating from the centre to near the margin. This has been termed *Stellettites callodiscus*, Carter, but it is not yet definitely known whether it really belongs to a tetractinellid Sponge.

Spicules of Fossil Calcisponges.

The spicules of calcisponges are much less varied in form, and likewise of much smaller proportions generally than the skeletal-spicules of fossil siliceous Sponges. The fossil examples, so far as at present ascertained, differ but slightly in form and size from those of recent Sponges of this group, but there is a special difficulty in studying them, since it is an extremely rare circumstance to obtain them detached, and their individual outlines can seldom be seen complete in microscopic sections of the fibres in which they are interlaced. Notwithstanding this drawback many of the modifications of the chief types of these spicules, which have been so exhaustively described by Haeckel in his "Kalkschwämme," can be recognised in fossil calcisponges.

1. Simple uniaxial spicules. These in microscopic sections can scarcely be distinguished from portions of three-rayed spicules, more particularly when the basal ray of these latter is only slightly developed. Dunikowski[1] has described fusiform spicules in *Elasmostoma* and *Pachytilodia* with pointed and rounded extremities, and *Pharetrospongia Strahani*, Sollas, seems to be entirely composed of straight or slightly curved uniaxial spicules.

2. Three-rayed spicules. In the simplest form or "regular" spicules, the rays are in the same plane and the rays and angles are equal (Fig. 7, *h*). These have been met with in a detached condition in tertiary deposits at St. Erth,[2] Cornwall, and at Goes in Holland, and forming the dermal layer of *Sestrostomella clavata*,[3] Hinde, from the Upper Greensand of Warminster. In the "sagittate" spicules two of the rays are paired and equal, and the third or basal ray may be either longer or shorter than the other two (Fig. 7, *i*). In spicules of this type, which are abundantly present in the fibres of *Tremacystia*, Hinde, *Corynella*, Zitt., and *Rhaphidonema*, Hinde, the paired rays form a very open angle or a regular curve, in the centre of which on the convex side is a small blunt projection representing the basal ray (Figs. 7, *j*, *m*). In another abnormal three-rayed sagittate spicule, occurring in *Sestrostomella*, Zitt., and also in the recent *Leucetta pandora*, Haeck., the paired rays are nearly parallel with each other and the basal ray extends backwards, so that the spicule is similar in form to a tuning-fork (Fig. 7, *n*). In the "irregular" three-rayed spicules all the rays and the angles are unequal.

The axial canal in the spicules of fossil calcisponges can very rarely be detected, but traces of its presence have been noted by Dunikowski in spicules of *Elasmo-*

[1] 'Palæontographica,' Bd. xxix, p. 11.

[2] 'Quarterly Journ. Geol. Soc.,' vol. xlii, p. 214.

[3] 'Ann. and Mag. Nat. Hist.,' vol. x, 1882, p. 202, pl. xii, fig. 25.

stoma[1] from the Cenomanian of Essen, and I have also observed it in detached spicules of *Leuconia* from the Pliocene beds of St. Erth.

3. Four-rayed spicules. These may be described as three-rayed spicules in which an additional ray radiates from the point of junction of the three rays either at right angles or obliquely. This fourth, or apical ray as it has been termed by Haeckel, is, in the fossil forms in which I have noticed it, frequently shorter than the three facial rays of the spicule (Fig. 7, *k*). Four-rayed spicules are present in the dermal layer of *Tremacystia D'Orbignyi*,[2] Hinde, and possibly in the dermal layer of other fossil calcisponges as well, but unless the spicules can be isolated it is difficult to determine whether a fourth ray is present or not. Four-rayed spicules are also present in the fibres of *Sestrostomella clavata*,[3] Hinde; in these the rays are curved.

The Disposition of the Spicules in the Skeleton.

The manner in which the elementary spicules, whose forms have just been described, are combined together to form the skeleton of the Sponge is very varied in the different groups. According to the nature of this union so is the capacity of the Sponge to resist the disorganizing influences of fossilization, and it probably explains the rarity in the fossil state of certain groups of Sponges which are extremely abundant in the present seas. We proceed to consider first the skeleton of siliceous Sponges.

Monactinellidæ and *Tetractinellidæ*. In these two groups, which form the large majority of existing siliceous Sponges, the spicular elements of the skeleton are not organically fused together, but are held in their natural positions by an envelopment of a horny substance known as spongin. In some Sponges this connecting substance is reduced to a small amount, which merely surrounds the terminal ends of the spicules, whilst in others the spicules are completely enveloped by it, and thus held together so as to form a meshwork of fibres, in which they are arranged parallel with each other, or they may be grouped in bundles which branch and anastomose, or radiate from the base to the summit of the Sponge. As this connecting horny substance inevitably decays on the death of the Sponge, the spicules become detached and fall apart, and only under very exceptional conditions of preservation does the skeleton retain its natural form in the fossil state. As a matter of fact, entire Sponges of these groups, or even connected fragments of the skeleton, are of the rarest occurrence,

[1] Op. cit., p. 12.

[2] 'Ann. and Mag. Nat. Hist.,' S. 5, vol. x, p. 192, pl. xi, figs. 1—8.

[3] Id., pl. xii, fig. 16.

though their detached spicules are sometimes sufficiently numerous to form whole beds of rock, as in the Upper Greensand[1] of the Isle of Wight and elsewhere.

Of the few fossil forms which have been discovered may be mentioned the genus *Haplistion*, Young and Young, from the Carboniferous strata of Scotland, in which the acerate spicules are closely arranged into anastomosing fibres (Plate V, figs. 1, 2); *Opetionella*, Zitt., from Cretaceous strata, in which the large acerate spicules are disposed side by side to form a thick lamina, and *Scoliorhaphis*, in which the spicules form meandriform laminæ. In a few instances Sponges of these groups have been enclosed in flints, so that the spicules retain their natural arrangement. In *Pachastrella*, O. Schmidt, the spicules are loosely aggregated together, without any apparent order, so as to form a thick wall. Entire examples have been preserved in the Upper Chalk of Flamborough, Yorkshire. In these and the other Sponges mentioned, the spicules, originally only held together by the spongin, are now for the most part lightly cemented and fused together by a secondary deposition of silica, produced during fossilization from a partial solution of the spicules themselves.

The polyaxile stellate, globostellate, and discoid spicules, which form the dermal layer in some tetractinellid Sponges, are, like the skeletal-spicules in these Sponges, merely held together in their natural position by the soft structures of the Sponge, and they have hitherto only been met with detached in the fossil condition.

Lithistidæ.—In this sub-order also the skeletal-spicules in their natural condition are not organically united, but the terminal extremities of the spicular rays are firmly linked together in various ways, so as to produce a resistant structure; owing to which, and to the further fact that the walls of these Sponges are often of considerable thickness, entire examples are of frequent occurrence in the fossil state. Their detached spicules are, however, extremely abundant in certain strata, thus showing that in many instances the union of the spicules has not been sufficiently strong to resist disintegration of the skeleton.

In the Tetracladina family the spicules are united together by the interlocking of the tubercular extremities of the twig-like subdivisions of their rays with those of proximately adjoining rays, so that a prominent rounded or oval node is produced by their combination, as in *Callopegma* (Fig. 5, *d*). These twig-like extensions of the rays are so intricately intertwined together that it is almost impossible to separate them without fracture of the more delicate portions. The skeletal mesh thus formed has irregular oval or polygonal interspaces. The spicular rays bounding the canals are deflected so as not to protrude into their channels, but there does not appear to be a specially modified membrane lining their walls.

[1] "Beds of Sponge Remains in the Lower and Upper Greensand of the South of England," 'Phil. Trans.,' part ii, 1885, p. 403.

In *Plinthosella*, Zitt., and *Phymaplectia*, Hinde, the spicules unite together by the interlocking of the tubercles on their lateral surfaces (Fig. 5, *e*) as well as terminally, without forming prominent nodes, thus showing an approximation to the mode of union in the Rhizomorina family.

In the Megamorina family there are two distinct modes in which the skeletal-spicules unite together, and both may take place in the same Sponge. In one, the spicules and their branches are twisted round each other almost in the same manner as the strands of whipcord. The spicules may be merely twisted at their ends, or throughout their length; and owing to the lateral and terminal notches (Fig. 4, *g*) they are very closely fitted together, so as to produce a fibrous meshwork. This mode of union is typically shown in *Carterella*, Zitt., and *Isorhaphinia*, Zitt. The second mode is exemplified in spicules, in which the branches terminate in flattened, concave, spoon-shaped expansions (Fig. 4, *e*), which closely and evenly fit, and clasp the surfaces of adjoining spicules, and thus form a meshwork of open irregular interspaces. This kind of union is well shown in *Doryderma*, Zitt. (Fig. 4, *f*), *Heterostinia*, Zitt., and in the recent *Lyidium*, Os. Schmidt.

In the Anomocladina family the union of the skeletal spicules takes place, in some respects, in the same manner as in the Megamorina family described above, that is to say, the terminal ends of the spicular rays are similarly furnished with expanded surfaces (Fig. 5, *a*, *b*), which are firmly attached to the central nodes, and occasionally to the rays of adjoining spicules, thus forming a mesh apparently composed of star-shaped bodies, whose rays are all united together (Fig. 4, *h*). These stellate bodies of the connected skeleton are thus of a compound character, for in each there is the node and the rays proper to it, forming the elementary spicule, and also other rays belonging to adjoining spicules whose terminal expansions are firmly attached to the node. This union is usually so close that it is not practicable to determine in the connected skeleton the rays proper to the node from those which are merely adpressed to it (Fig. 4, *h*). In some instances, in the skeleton of *Astylospongia*, the spicular rays converge to a point in which no central node is present for them to clasp, but they terminate in precisely the same way as if the node were in the proper position, and are thus grouped round a sub-spherical cavity. In some examples of *Cylindrophyma*, the rays project from the node at right angles to each other, and the connected skeleton has quadrate or subquadrate interspaces, singularly resembling the mesh of hexactinellid Sponges, for which it has sometimes been mistaken. Typical examples of the skeleton of Anomocladina Sponges are shown in *Cylindrophyma*, Zitt., *Astylospongia*, Ferd. Roem. (Fig. 4, *h*), and the recent *Vetulina*, Os. Schmidt.

The skeletal-spicules of the Rhizomorina family are united together by the close adpression of the minute facets terminating the numerous branches and spinous processes of the spicules, to the main axis and branches of adjoining

spicules (Fig. 4, *b*). As these facets are very numerous, and radiate in all directions from the main axis of the spicules, they form by their union an extremely intricate meshwork with minute irregular interspaces. In some instances the spicules thus united produce anastomosing fibres with open interspaces, in which the circulation is carried on, as, for example, in *Pachinion*, Zitt.; in others, as in *Seliscothon*, Zitt., they form thin vertical lamellæ.

The spicules of the dermal layer in lithistid Sponges are arranged so that the small vertical ray penetrates into the wall of the Sponge, whilst the horizontally extended head-rays cover the outer surface, frequently overlapping each other, thus forming a smooth covering with only microscopic interspaces. They are not organically attached to each other, or to the skeletal spicules, and it is very seldom that they have been preserved *in situ* in the fossil state. In some cases the dermal spicules appear to have extended over the cloacal surface as well as over the exterior of the Sponge. In the genus *Dorydcrma*, the trifid spicules of the dermal layer are tightly packed, with their shafts parallel to each other, into the open meshes of the skeletal-spicules, and their head-rays project, like arrows in a quiver.

Hexactinellidæ.—In this division the six-rayed spicules are disposed so that their rays overlap each other, and produce a framework which, when regularly developed, has quadrate or subquadrate boundaries. The spicules may be simply held in position by the sarcode or fleshy portion of the Sponge, or they are united organically together by a common siliceous sheath. Fossil examples of those Sponges in which the spicules are not organically fused together are very rare, though the detached spicules are extremely abundant. Judging by existing forms of these Lyssakine Sponges, the spicules are generally arranged into elongate, loose fasciculate fibres or open tissues, which in some genera, as in *Euplectella*, for example, cross each other in regular lines. Not strictly in all cases are the spicules free from each other, for they are sometimes soldered together laterally, and at the crossing of some of the larger rays, by a deposit of silica. In many recent Lyssakine Sponges the spicules of the dermal layer have the same regular arrangement as those of Dictyonine Sponges, and form a meshwork with quadrate interspaces, but the spicules are not fused together. A fragmentary example of this is shown in *Hyalostelia Smithii* (Pl. VI, fig. 1). The elongated spicules of the anchoring rope of this group of Sponges are disposed either parallel to each other, so as to form rounded or compressed fascicles (Pl. I, fig. 3; Pl. VI, figs. 2, 3 *d*), or they extend singly through the rock. Though the component spicules of these ropes are not organically attached together, yet they are found in close contact with each other for considerable distances, and this undisturbed arrangement may probably be owing to the circumstance that these anchoring ropes were embedded in the mud during the life of the Sponge, and were thus preserved from disintegration after its death.

In the Dictyonine division of hexatinellids, the overlapping rays of adjoining spicules are enclosed and united with each other in a common, regular, even coating of silica, so as to form a continuous fibrous meshwork, the faces of which may be squares (Fig. 6, *f*) or polygons. The individuality of the component spicules in this continuous meshwork cannot be recognised on the exterior, but it is shown by the internal canals of the rays, which can be seen to extend from each of the nodes of the mesh and to overlap those proceeding from adjoining nodes. In some instances the internal canals appear to be continuous from node to node, as in *Sestrodictyon* (Fig. 6, *e*), but this probably arises from the breaking down in the fossilization of the delicate partitions dividing them. The regular quadrate or cubical arrangement of the spicular meshwork is frequently interrupted by the irregular interposition of spicules, the rays of which may become fused to the nodes or centres of other spicules, or even to the lateral portion of their rays, producing a confused meshwork, in which the original hexactinellid form of the spicules is largely masked. This irregular structure is more especially developed where the spicular structure is minute, and there are numerous canals in the sponge-wall, as in *Leptophragma*, Zitt., and *Coscinopora*, Goldf.

The union of the spicules in the dermal layer of hexactinellids in most cases differs very considerably from that of the interior meshwork of the skeleton. This dermal layer, in some instances, consists of a delicate siliceous membrane with circular or polygonal apertures. No individual spicules can be seen on the exterior of this membrane, but when examined by transmitted light the membrane is seen to consist of a framework of irregularly-scattered four- or six-rayed spicules, the canals of which still remain, and between these the delicate membrane has been deposited. This kind of dermal layer is shown in *Craticularia*, Zitt., *Guettardia*, Mich., *Plocoscyphia*, Reuss, and other genera. It is not merely limited to the outer and cloacal surfaces of the Sponge, but frequently lines the canals and inter-canals. In another modification, the dermal layer consists of large cruciform or five-rayed spicules, irregularly disposed and soldered together where the rays touch or cross each other; sometimes also connected by siliceous balks or rods or even by a siliceous membrane, as in the genus *Cypellia*, Pom. Sometimes also the skeletal mesh of the Sponge is irregular, whilst the spicules of the dermal layer form a very regular connected quadrate meshwork, as in *Casearia*, Quenst. In the existing genus *Sclerothamnus*, Marshall (=*Dendrospongia*, Murie), the spicules of the dermal layer are regularly disposed to form a quadrate meshwork, but the rays are not cemented together, and remain free, similar to those of the dermal layer of Lyssakine Sponges; thus in this genus the skeletal mesh is formed by united spicules, and therefore Dictyonine in character, whilst the dermal layer is distinctly Lyssakine. In the Cretaceous genus *Cincliderma*, Hinde, there is a dermal layer of large spicules forming a regularly

quadrate framework, and the interspaces are filled by numerous irregularly arranged cruciform or five-rayed spicules, the whole forming a smooth, connected, surface membrane. In the enveloping dermal layer of *Cystispongia*, Roem., and *Camerospongia* (D'Orb.), the siliceous membrane is very fine and delicate, and no traces of spicules or of their axial canals can be detected in it.

Octactinellidæ.—In this small group, only represented by the genus *Astræospongia*, the skeletal spicules do not appear to have been attached in any way to each other, but they are distributed without apparent arrangement beyond that the stellate disc is generally parallel to the upper surface of the Sponge. The spicular rays rest upon and cross over each other, but without leaving any definite interspaces or canals. There are no indications of a special disposition of the spicules on the outer surface of the Sponge to form a dermal layer.

Heteractinellidæ.—The skeletal-spicules in this group appear to have been distributed quite irregularly in the body of the Sponge, their rays interlacing with each other loosely, and the smaller spicules filling in the spaces between the rays of the larger forms. In some instances, fragments of the skeleton are met with in which the spicular rays are lightly cemented together; but this probably results from a secondary deposit of silica during fossilization, like that which occurs in the tetractinellid *Pachastrella* from the Chalk of Flamborough.

In the dermal layer of some of the Sponges of this group the spicules are disposed so that their disc-rays interlace and fit into notches in adjoining rays (Pl. VII, fig. 1 *b*), whilst the radial ray projects into the interior of the sponge-wall (Pl. VII, figs. 1, 2). The rays also are, in some instances, partially fused together, in others they are compressed and completely united with those of adjoining spicules, so that there are only small oval apertures in the dermal layer (Pl. VII, fig. 3).

Calcisponges.—In the large majority of fossil calcisponges the skeletal-spicules are arranged side by side in close contact with each other, so as to form cylindrical fibres, which anastomose together. The spicules do not appear to be organically attached or fused together in any way, and it is somewhat surprising that the fibres thus composed should have in so many instances resisted disintegration. In some cases there is a relatively large axial spicule in the centre of the fibre, which is enveloped by smaller filiform spicules; whilst in others the spicules are throughout equal or subequal. In one genus (*Protosycon*) the spicules appear to have the same arrangement as in the existing Sycones, that is to say, they form a series of horizontal tubes.

The four-rayed spicules of the dermal layer in some instances are irregularly disposed over the outer surface of the Sponge, and the apical ray is directed into the sponge-wall; in other cases the spicules are irregularly and closely mingled together, so as to produce an apparently compact, smooth, or wrinkled membrane.

Systematic Position and Classification.

The position of Sponges in the animal kingdom may now be said to be decided generally in favour of their belonging to the Metazoa, but there is not the same unanimity of opinion as to whether they should be included in the Cœlenterate type or placed independently as the lowest division of the Metazoa. It is a question which can only be decided by a consideration of the embryological development and the soft structures of the organism, and no light whatever is thrown on it by the fossil forms. So long since as 1867, Sponges were regarded as Cœlenterata by Leuckart, and this view has gradually been accepted by most authorities on the subject till within a recent period; but at the present time the opinion that they represent a type distinct from the Cœlenterata seems to be most in favour. Similar differences of opinion also exist with respect to the classification of existing Sponges, and nearly every recent author on the subject propounds a distinct system, differing alike in the main as well as in the subordinate divisions from those previously advanced. Attempts have even lately been made to arrange the Sponges according to the characters of their soft structures, but it need hardly be said that any system on this basis would be entirely useless for fossil forms, in which only the mineral portions of the skeleton are available for purposes of classification.

As regards the classification of fossil Sponges, it seems scarcely necessary to mention the various systems in use previous to that brought forward by Professor Zittel, since they are now regarded as obsolete, and possess a mere historical interest. The main features of Zittel's classification, which I propose to adopt with some modifications, depend on the characters of the skeletal elements of the organism. The following list shows the leading divisions.

Class: SPONGIÆ.

Order I. Myxospongiæ, *Haeckel.*
,, II. Ceratospongiæ, *Bronn.*

	Sub-Order.
,, III. Silicispongiæ	1. Monactinellidæ, *Zittel.*
	2. Tetractinellidæ, *Marshall.*
	3. Lithistidæ, *Os. Schmidt.*
	4. Hexactinellidæ, *Os. Schmidt.*
	5. Octactinellidæ, *Hinde.*
	6. Heteractinellidæ, *Hinde.*

,, IV. Calcispongiæ, *Blainville.*

Class: SPONGIÆ.

Definition.—Bodies of very variable form, consisting principally of a soft fleshy mass, enclosed by an epithelium of a single layer of cells. The body is penetrated by a system of canals opening into chambers, and communicating with the exterior by numerous smaller apertures or pores, and larger or vents. In the majority of forms the body is supported by a skeleton, which is composed either of horny fibres or of siliceous or calcareous spicules.

Order I.—Myxospongiæ.

Sponges without any skeleton, or with only a few scattered siliceous spicules (v. Lendenfeld).[1] Unknown as fossil.

Order II.—Ceratospongiæ.

Sponges with skeletons of horny fibres, which may contain foreign bodies but not proper spicules. Siliceous spicules rarely present, scattered in the mesodermal tissues (v. Lendenfeld).

No Sponges of this group are definitely known as fossils, the form described as such by Carter under the name of *Dysidea antiqua* being a siliceous monactinellid, whilst the reputed horny Sponges, known as *Spongites*, are of an altogether doubtful character.

Order III.—Silicispongiæ.

Sponges with skeletons of siliceous spicules, either held in position by the soft portions of the Sponge, or united together in various ways to form skeletal fibres.

Sub-Order 1.—Monactinellidæ.

The skeletal-spicules possess a simple unbranched axis. They may be enclosed in distinct fibres or merely held together by spongin. The usual forms are acerate, acuate, cylindrical, or conical. Flesh-spicules of various forms may or may not be present.

Owing to the mode in which the spicules are held together by the fleshy or horny parts of the organism, entire Sponges, or even fragments, are of very rare

[1] "Monogr. Austr. Sponges," 'Proc. Linn. Soc. New South Wales,' vol. ix, 1884, p. 339.

occurrence in the fossil state. Detached monactinellid spicules are, however, very abundant in certain strata, but though many of these most probably belong to the next sub-order, there are others which may undoubtedly be regarded as pertaining to this group. The families of the existing Monactinellidæ are, to a certain extent, based on characters which cannot be applied to the fossil spicules; but the following appear to be represented: Halichondridæ, Desmacidonidæ, Suberitidæ, and Spongillidæ.

Sub-Order 2.—Tetractinellidæ.

Sponges with skeletal-spicules normally of four rays or axes, disposed like the four axes of a regular three-sided pyramid. One ray frequently more developed than the others, so as to form a long shaft. Uniaxial spicules of large size usually present. Skeletal-spicules frequently disposed in fascicles with a radiate arrangement. Spicules held together by spongin. Polyaxonal spicules in the form of stellates, globostellates, and discs frequently present.

Representatives of two at least of the existing families of this sub-order, Geodidæ and Ancorinidæ, are present as fossils, but from their imperfect condition of preservation it is impracticable to determine in most of the fossil forms the characters which distinguish the respective families.

Sub-Order 3.—Lithistidæ.

Sponges of a stony character, usually with thick massive walls. Skeletal-spicules either four-rayed or altogether irregular in form, usually branching at their extremities, which terminate obtusely, or with minute expanded surfaces. Spicules firmly united together by the intertwining of their branches, or by the close apposition of their expanded extremities, but not fused together. A surface or dermal layer of trifid spicules or small discs is usually developed, as well as minute uniaxial flesh-spicules. Large skeletal uniaxial spicules occasionally present.

This sub-order has been divided by Zittel into the following four families:

Family 1.—Rhizomorina.

Skeletal-spicules usually elongate and irregularly branching, with minute projecting spines. Branches terminating in minute facets, which are closely apposed to the axis and branches of adjoining spicules, forming an irregular meshwork or

confused fibres. A canal in the main axis of the spicules. Dermal layer either of spicules resembling those of the skeleton, or of compound trifids.

Family 2.—Megamorina.

Skeletal-spicules large, elongate, smooth, straight or curved, simple, or irregularly branching. A canal in the main axis of the spicule. Branches terminating obtusely or with expanded facets. Spicules united by being intertwined together or by the apposition of their terminal facets, forming an open meshwork. Small spicules of the Rhizomorina type occasionally filling the interspaces of the mesh. Dermal layer of compound trifid, or minute uniaxial spicules.

Family 3.—Anomocladina.

Skeletal-spicules consisting of a central sub-spherical node, from which a variable number of simple or furcate arms, with slightly expanded terminations, radiate in different directions. In some cases the nodes are in twins connected by a short axis, in which a canal is present, and the rays are partially spined. Spicules united by the apposition of the expanded terminations of the rays to the nodes, and occasionally to the branches, of adjoining spicules, so as to form a regular meshwork.

Family 4.—Tetracladina.

Skeletal-spicules of four rays extending from a common, non-inflated centre, approximately at angles of 120°. Rays smooth or tuberculated, with branching extremities, which interlock with those of adjoining spicules to form the mesh. An axial canal in each of the spicular rays. The spicules of the dermal layer are either compound trifids, entire or lobate discs, or irregular laminæ, and also minute uniaxial spicules.

Sub-Order 4.—Hexactinellidæ.

The skeletal-spicules normally consist of six rays, radiating from a common centre, at right angles to each other. An axial canal is present in each ray. The spicules are arranged so that their rays overlap each other and form a lattice-like mesh with cubical or irregular interspaces. They are either united together by a common siliceous envelope, or interlaced and held in position by the soft structures. Two main groups Dictyonina, Zitt., and Lyssakina, Zitt.

Group.—Dictyonina.

The skeletal-spicules are normal hexactinellids, whose rays are fused together by a common siliceous envelope so as to produce a firmly-united meshwork, which, when regular, has cubical interspaces. The spicular nodes or centres may be either simple or octahedral. A dermal layer of modified six-rayed spicules usually present. Flesh-spicules may be present or absent.

Family 1.—Euretidæ, *Zitt.*

Sponges cup-shaped, cylindrical, turbinate, laminate or branching. Skeletal mesh regular; the spicular nodes simple. The dermal layer consists of a thickening of the exterior layer of the skeletal mesh, occasionally also a delicate meshwork extends completely over the surface, and covers the apertures in the sponge-wall. The structure of the root-appendage similar to that of the body of the Sponge.

Family 2.—Coscinoporidæ, *Zitt.*

Sponges cup-shaped, branching, frequently compressed, or with flange-like walls extending from a centre. Very numerous, simple, straight, blind, radiate canals, which open alternately on both sides of the sponge-wall. Skeletal mesh close, and, owing to the numerous canals, irregular. Spicular nodes usually simple, but occasionally octahedral. Dermal layer, when present, a cribriform membrane.

Family 3.—Mellitionidæ, *Zitt.*

Sponges irregularly globular or branching. Walls completely perforated by tubular canals, resembling the cells of honeycomb. Spicular nodes simple. Meshwork irregular. Dermal layer, a delicate siliceous meshwork which covers also the canal-apertures.

Family 4.—Callodictyonidæ, *Zitt.*

Sponges cup-, funnel-shaped, or compressed. Spicular mesh large and regular; spicular nodes octahedral. Dermal layer cribriform. No special canals shown in skeleton.

Family 5.—Protospongidæ, *Hinde*, n.

Sponges cup- or funnel-shaped. Skeletal mesh apparently consisting of a single layer of modified hexactinellid spicules, forming quadrate areas of various dimensions. Spicules appear to be embedded in a delicate siliceous membrane.

This family is proposed to include *Protospongia*, Salter, *Phormosella*, Hinde, *Plectoderma*, Hinde, and possibly also some of the forms included under *Dictyophyton*, Hall. The structure of the sponge-wall resembles that of the dermal layer of some of the Sponges of the next family, but, unlike these, no interior meshwork is present. Owing to the imperfect condition of preservation, the nature of the sponge-wall is not clearly shown; by some authors the spicules are believed to be free from each other, and thus of a Lyssakine character.

Family 6.—Staurodermidæ, *Zitt.*

Sponges turbinate, funnel-shaped, cylindrical, rarely branching. Interior skeletal mesh irregular, spicular nodes simple or octahedral. Dermal layer of cruciform or five-rayed spicules forming a regular or irregular framework; in the interspaces a siliceous membrane of smaller spicules.

Family 7.—Ventriculitidæ, *Toulmin Smith* (emend. *Zitt.*).

Sponges simple or compound, cup-, funnel- or top-shaped, cylindrical or ramose. Wall in meandrous folds. Spicular nodes octahedral. Radial canals blind. The outer or under surface of the Sponge with elongate apertures or furrows, the inner or upper surface either similar to the lower or with circular vents. Dermal layer a cribriform siliceous membrane. Root-appendage of fasciculate, siliceous fibres, united by transverse extensions, and without axial canals.

Family 8.—Mæandrospongidæ, *Zitt.*

Sponges of variable form, consisting of laminate walls in meandrous folds, which anastomose together, frequently forming open tubes. Walls with radiate blind canals, or with the ordinary apertures of the mesh. Inter-canal system always present. Spicular nodes either simple or octahedral. Dermal layer, when present, a continuous cribriform membrane either partially or entirely enclosing the anastomosing walls.

Family 9.—Cœloptychidæ, *Zitt.*

Sponges with flattened or depressed disc-shaped summits supported on short stems. Interior skeleton of thin laminated walls, folded so as to divide the central cavity into radial chambers. Skeletal mesh regular, with relatively large interspaces; spicular nodes octahedral. Dermal layer of the upper surface a siliceous membrane with alternately arranged coarse and fine cribriform areas. The vents on the summits of the ridges of the under surface, occasionally also on the stem.

Group.—Lyssakina, *Zitt.*

Skeletal-spicules interlaced and either held in position by the fleshy structures of the Sponge, or exceptionally cemented together irregularly and united by siliceous outgrowths. Spicules often peculiarly modified, their nodes always simple. Flesh-spicules of various forms usually present, also anchoring-ropes of elongated spicules.

Family 1.—Pollakidæ, *Marshall.*

Skeletal-spicules may be simple hexactinellids or forms greatly modified by the reduction or subdivision of the normal rays, also by the unusual development of one or more of the rays. A distinct dermal layer present. Flesh-spicules of varied forms. Anchoring-appendage of elongate spicules, either in bundles or extending singly from the body of the Sponge.

Family 2.—Receptaculitidæ, *Eichwald*, pars, emend. *Hinde.*

Sponges open cup-shaped, turbinate, sub-spherical and conical, free. The distal ray of the skeletal-spicules modified into a rhomboidal or polygonal plate. The spicules disposed so that the outer plates form a smooth surface of regular oblique, curved, or spiral rows, whilst the four transverse rays mark radial and concentric lines beneath the surface. A perforate inner layer present in one genus.

Sub-Order 5.—Octactinellidæ.

Skeletal-spicules normally of eight rays, six of which are in a horizontal plane, radiating at equal angles from a common centre, whilst the other two rays, which

are frequently reduced or absent, form a vertical axis. Spicules merely held in position by the soft structures of the Sponge. This sub-order is represented by the single genus *Astræospongia*, Ferd. Roemer.

Sub-Order 6.—Heteractinellidæ.

Skeletal-spicules consisting of an indefinite number of rays, varying from six to thirty, radiating from a common centre. The body-spicules irregularly arranged and held in position by the soft structures of the Sponge. The spicules of the dermal layer are interwoven together, and their rays partially or completely fused with each other.

Order IV.—Calcispongiæ.

Sponges whose skeletal spicules are composed of carbonate of lime. Spicules either uniaxial, three-rayed, or four-rayed. They are either regularly arranged to form the skeleton, or loosely distributed in the soft tissues, or closely apposed together to form anastomosing fibres. Only two families have up to the present been definitely recognised in the fossil state.

Family, Pharetrones, *Zitt.*

Skeletal-spicules arranged in the form of solid anastomosing fibres. Canals branching irregularly, at times not indicated in the skeleton. Dermal layer forming a continuous smooth or corrugated membrane.

Family, Sycones, *Haeckel.*

Skeletal-spicules very regularly arranged to form transverse simple radial tubes or chambers, which open into a central cloaca. A distinct dermal and cloacal layer present.

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A MONOGRAPH

OF THE

BRITISH

FOSSIL SPONGES.

BY

GEORGE JENNINGS HINDE, Ph.D., F.G.S.

PART II.

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PART II.

SPONGES OF THE PALÆOZOIC GROUP.

PRELIMINARY REMARKS.

Up to a comparatively recent period so few genuine fossil Sponges were known from the older stratified rocks of the British area, that it would have been superfluous to devote a separate portion of a Monograph especially to their consideration. Even now the number of species is very limited in comparison with those from the Mesozoic strata, and their state of preservation is very unfavorable; but recent discoveries show that Sponges as a group flourished to such an extent in certain epochs of the Palæozoic era as to form by their remains massive beds of rock of considerable thickness, and, measured by this scale, they were then more numerous than at any subsequent geological period.

In view of this enormous development of Sponge-life, it is reasonable to suppose that the small number of species known hitherto falls far short of those which then existed. In no group of organisms with structures capable of preservation have the influences of fossilisation acted with more destructive effect than upon fossil Sponges; at all events, on those in the Palæozoic rocks; for thick beds occur built up almost exclusively of their remains, and yet not a single entire individual has been preserved in them! Their elaborate skeletal tissues have been altogether disintegrated, and only their minute, microscopical, spicular elements, heterogeneously mingled and cemented together into hard rock, remain for examination.

Under more favorable conditions entire Sponges and fragmentary portions of the connected skeleton are occasionally met with, but at the best the materials for the classification and description of these organisms are very imperfect and unsatisfactory, and such as would be rejected by the student of the living forms as altogether insufficient to furnish generic or specific characters. But since more perfect materials are not available, the palæontologist is compelled to make the most of those which are at his disposal. It will readily be conceded that the

characters of genera and species, based on skeletal fragments or even on detached spicules merely, must be limited and provisional, but at the same time there is no reason to doubt that these fragments and spicules really represent distinct species, and may justly be regarded as such.

Owing to the indefinite ideas formerly held as to the nature of fossil Sponges, it has been my especial endeavour to examine the type specimens of all the species hitherto described. The desirability of this revision of authentic specimens is shown by the long list of bad and doubtful species given in the sequel. Of the total number of reputed species of Palæozoic Sponges up to 1883, I find that only one-third belongs to the group, the remaining two-thirds being either too obscure for determination or pertaining to other organisms.

In the preparation of this part of the Monograph I have received much valuable assistance from numerous friends and fellow-workers, to whom I return my warm acknowledgments. The fossil Sponges preserved in the National Museum at South Kensington, in the collections of the Geological Survey at Jermyn Street, and at Edinburgh, and in the Woodwardian Museum at Cambridge, and the University Museum at Oxford, have freely been placed at my disposal; and to Dr. H. Woodward, F.R.S., Dr. A. Geikie, F.R.S., Prof T. McKenny Hughes, M.A., and Prof. J. Prestwich, F.R.S., my thanks are especially due for the opportunities of studying them. I am also under great obligations to Mr. John Smith, Kilwinning, Mr. John Young, F.G.S., Hunterian Museum, Glasgow, Dr. J. R. S. Hunter, Carluke, and Mr. James Bennie, Edinburgh, for the unstinted loan of their private collections from the Carboniferous series of Scotland; whilst Mr. J. Wright, F.G.S., Belfast, sent me his specimens from the same series in Ireland. Prof. R. J. Anderson, M.A., enabled me to examine the type collection of supposed Permian Sponges described by the late Prof. King, and now in the Museum of Queen's College, Galway. I have also received many specimens, including type forms, from my friend Mr. H. J. Carter, F.R.S., Prof. H. Alleyne Nicholson, F.L.S., Prof. C. Lapworth, F.G.S., Mr. G. H. Morton, F.G.S., Mr. J. Thomson, F.G.S., Glasgow, and the late Mr. A. Champernowne, F.G.S.

General Features of the British Palæozoic Sponges.

Notwithstanding their unfavorable state of preservation, the presence in the British area during Palæozoic times of representatives of the various existing sub-orders of siliceous Sponges can be undoubtedly proved; and, in addition to members of the Monactinellidæ, Tetractinellidæ, Lithistidæ, and Hexactinellidæ, there are other forms, included in the Octactinellidæ and Heteractinellidæ, which are not as yet known later than the Carboniferous period.

The Monactinellidæ are represented by four genera, *Reniera*, *Axinella*, *Atractosella*, and *Haplistion*. Entire Sponges and fragments of the connected skeleton of *Haplistion* have been preserved, but the other genera are only represented by detached spicules. These, however, so closely resemble the skeletal-spicules of existing species of these genera, that the generic affinity of the ancient with the recent forms can hardly be doubted. With the exception of the peculiar spicules from the Silurian referred to *Atractosella*, monactinellid Sponges in our area do not appear in force until reaching the Carboniferous. Some of the cherty Sponge-beds in the Yoredale series of Yorkshire and North Wales, and at a corresponding horizon in Sligo, Ireland, mainly consist of the minute, detached, cylindrical spicules of *Reniera*, several species of which appear to be present. The pin-shaped spicules referred to *Axinella* are comparatively rare, and only occur in the Carboniferous; and *Haplistion* is likewise limited to the same formation in the West of Scotland.

The Palæozoic Tetractinellidæ belong to the widely distributed genera, *Geodites* and *Pachastrella*. They are as yet only known by detached acerate, trifid, and four-rayed spicules, and by the reniform spicules of the dermal layer of the former genus. Their first appearance is in the Carboniferous, and they play an important part in building up some of the Sponge-beds of the Yoredale series in Yorkshire. One species, *Geodites deformis*, from the Carboniferous of Ayrshire, is remarkable for the relatively large size of the spicules.

The Lithistidæ are very sparingly represented in our Palæozoic rocks by four genera; of these *Cnemidiastrum* and *Doryderma* are only known by detached spicules. Only a single example of *Astylospongia* has been discovered, and in this the spicular structure has been obliterated so that its identification is not altogether certain. The genus is of such common occurrence in the Silurian strata of North America and the Isle of Gothland, that its comparative absence in the British area is worthy of note. The genus *Hindia*, again, which has a similar wide distribution, is only known in this country by a single fragment lately discovered in the Ordovician strata of Ayrshire, and some detached spicules in the Carboniferous Rocks. Another well-marked Silurian genus, *Aulocopium*, Oswald, very abundant in the Baltic basin, is entirely absent in this country.

Hexactinellid Sponges are by far the most numerous in the Palæozoic strata. Twelve genera belonging to this sub-order are known, some, however, only from detached spicules or small fragments of the connected skeleton. The earliest known fossil Sponge, *Protospongia fenestrata*, Salter, from the Menevian beds of South Wales, is included in this sub-order. The genus *Hyalostelia* is the most widely distributed; it is present in every division of the Palæozoic Rocks, except the Devonian. The Sponges of this genus, like the existing *Hyalonema*, were furnished with bundles or wisps of elongated rod-like spicules which served to

attach the organism to the sea bottom. These bundles of anchoring spicules are more frequently preserved than the six-rayed spicules of the body of the Sponge, and they have been found in the Tremadoc rocks of Wales, and the Ordovician of Girvan, Ayrshire; but they are more particularly abundant in the Sponge-beds of the Yoredale series in Yorkshire and in the decayed chert of the corresponding rocks in the West of Scotland and Ireland. Entire beds of rock in Yorkshire are filled with them.

The genus *Dictyophyton* is only represented by a small form, which appears to be limited to Ludlow strata near Kendal, whilst it seems to be entirely absent from the Devonian strata in this country. In North America, on the other hand, and in Belgium, this genus has a great development in the Upper Devonian.

Plectoderma is as yet only known by a fragment of the connected skeleton, it is limited to the Upper Silurian of the Pentland Hills. *Phormosella* is likewise restricted to a single horizon of the Silurian in Shropshire. Like many of the Palæozoic hexactinellids, it appears to have been a gregarious form.

Whilst the spicular characters of many of the Palæozoic hexactinellids correspond closely with those of existing Sponges of this division, there are others in which the spicules are greatly modified, and widely diverge from the normal type. Thus in the Carboniferous genus *Spiractinella*, Hinde, the rays are ornamented with a spiral ridge; and, though simple six-rayed spicules occur, in the majority the rays divide and subdivide, so that the extreme forms are stellate. In *Holasterella*, Carter, stellate spicules are likewise present, and the larger spicules of the skeleton also appear to be very irregular in form. Still more abnormal are the large branched and spined spicules of *Acanthactinella*, Hinde, from the Carboniferous of Ayrshire. In *Amphispongia* again, limited to a single horizon of Upper Ludlow age, and to a single locality in the Pentland Hills, the spicular structure strikingly differs from that of any other hexactinellid genus. In the well-marked family of the Receptaculitidæ, one ray of the normal hexactinellid spicule is modified into a delicate plate.

Only detached spicules of the genus *Astræospongia* have as yet been met with in the Silurian and Devonian strata of Shropshire and Devonshire, though in North America, and in Germany, entire Sponges are occasionally preserved.

The most striking of any of the Palæozoic Sponges are the forms which I have described under *Tholiasterella* and *Asteractinella*, and placed in a new sub-order, the Heteractinellidæ. Their spicules are of unusually large dimensions; the number of rays is variable, ranging from six to thirty, and they are disposed so as to form either stellate or umbrella-shaped spicules. The spicules appear to have been partially free and partially fused together in the skeleton. These remarkable forms have as yet only been found in the Carboniferous Rocks of Ayrshire.

The only examples of the *Calcispongiæ* yet discovered in our area are minute detached spicules in the Carboniferous Rocks of Fifeshire.

Geological Distribution.

Cambrian System.—The lowest rocks in which fossil Sponges have been met with are hard, black, slaty beds, belonging to the Menevian series near St. David's, South Wales. The examples of *Protospongia* occurring in them, have their spicules replaced by iron-pyrites or iron-peroxide. The same genus is present in nearly similar rocks at Krekling and other places in Norway, associated with *Paradoxides.*

In hard, slaty rock of the Tremadoc series, near St. David's, the earliest known example of *Hyalostelia* was discovered by Dr. Hicks, F.R.S.

Ordovician System.—In the Llandeilo district of North Wales, at Tre Gil, South of Llandeilo, Pont Ladies, and near Shelve, in Shropshire, the anchoring spicules of *Hyalostelia* are of not unfrequent occurrence in the hard, dark, calcareous shales of the Llandeilo series. The same genus is present in a dark slaty rock at Dobb's Linn, Moffat, Dumfriesshire, as well as in light grey limestones of Ordovician age, in the Girvan area of Ayrshire; and from the same rocks Professor H. A. Nicholson has obtained *Hindia fibrosa*, Roemer. In a slaty rock of Lower-Llandeilo age at Garn, Arenig, Wales, *Ischadites* makes its first appearance. The Caradoc shale of Haverfordwest, South Wales, has yielded a single pyritized example of *Astylospongia.*

Silurian System.—Alike in the calcareous shales of the Wenlock and Ludlow series, the genus *Ischadites* is widely distributed. At Woolhope, in the Dudley and Malvern areas, Usk, near Buildwas, Shropshire, examples have been met with.

In the Dudley and Malvern areas, spicules of *Astræospongia* are sparsely present, and near the "Craven Arms," Shropshire, *Hyalostelia* and *Atractosella* are found in decayed limestones.

A well-marked horizon for fossil Sponges occurs in the Pentland Hills, near Edinburgh. The rock is a decayed limestone of Upper-Ludlow age. It is characterised by *Amphispongia;* examples of *Plectoderma* and *Ischadites* also are present in it. At Mocktree, Shropshire, a sandy rock of Aymestry age is characterised by *Phormosella;* and the only British examples of *Dictyophyton* have been met with in arenaceous beds of Upper-Ludlow age, near Kendal, Westmoreland.

Devonian System.—In the limestones of the typical area of this system, at Newton Bushell, Devonshire, *Sphærospongia* occurs; at the adjacent Newton Abbot detached spicules of *Astræospongia* are present in decayed limestones, and at Mud-

stone Bay a single specimen of *Receptaculites* was discovered by the late Mr. Champernowne.

Carboniferous System.—In the earlier rocks of the Palæozoic group, fossil Sponges are, as a rule, of rare occurrence, and they are altogether insufficient to impress a distinctive character on the rocks in which they are found, but in certain portions of the Carboniferous epoch they existed in such great numbers, and for such prolonged periods, that by the gradual accumulation of their broken-up skeletons beds of chert and siliceous rock of considerable thickness have been formed. Owing to the microscopic dimensions of the elementary spicules of which these rocks are mainly composed, and to the fact that subsequent changes have greatly altered and partially obliterated their original characters, the organic origin of these rocks, though oftentimes suspected, has not hitherto been satisfactorily ascertained. But from a microscopical examination of specimens which I have myself obtained from the chert and siliceous rocks of the Yoredale series of Yorkshire and North Wales, and from the corresponding horizon in Ireland, I have discovered that these rocks are composed of the débris of siliceous Sponges, and that they are veritable Sponge-beds.

In some cases these Sponge-beds occur as irregular, nodular masses, or accretions of grey or dark chert, in the midst of beds of limestone, resembling in appearance flints in chalk ; in others, the chert forms distinct beds, often variously banded, from one or two inches to eight feet in thickness (·025—2·43 m.). These chert beds appear to be free from limestone. Frequently, however, the Sponge-beds assume the form of grey or dark, compact, fine-grained siliceous rocks, distinctly bedded, and often having a mottled or banded structure. Occasionally a small proportion of lime is present in them.

Only exceptionally are the spicular contents of these rocks visible to the unaided sight, in the majority of cases they can only be seen in thin sections under the microscope or with the aid of a platyscopic or other good lens. Thin sections of the least altered specimens show a confused mass of spicules of various forms and sizes, thickly and indiscriminately mingled together, but usually with a generally horizontal arrangement in the plane of the rock-bedding. These spicules appear to be perfect in form, and their axial canals in many cases have been preserved. In general, however, they have been altered in various degrees by the effects of fossilization, so that it is possible in a series of sections, or even in different parts of the same section, to trace the gradual changes from rocks filled with spicules nearly in their original condition, to those in which they have become merged into a matrix of translucent silica, leaving but few traces of their former presence.

It is difficult to ascertain the characters of the spicules merely from sections of the rocks, but in a few cases the cherty Sponge-beds have decayed in such a manner that their component spicules, or at least the larger forms, can be obtained

free from the matrix; and it is from decayed material of this description that Mr. J. Smith, Mr. John Young, and Mr. J. Bennie have obtained the remarkable spicules of *Hyalostelia*, *Tholiasterella*, and other genera (Pls. VI, VII, VIII), and Mr. J. Wright those of *Spiractinella* (Pl. VIII). Not infrequently also the spicules on the outer portions of the Sponge-beds weather out naturally so that their forms can be ascertained.

In some of the Sponge-beds the anchoring- and body-spicules of hexactinellid Sponges appear to predominate; other beds are mainly made up of very minute acerate and cylindrical spicules of monactinellid Sponges, whilst in others, larger acerates and occasional trifid spicules indicate that tetractinellid Sponges contributed largely to the contents of the bed.

The Carboniferous Sponge-beds referred to above are principally developed in the upper portion of the Yoredale series, between the summit of the Carboniferous Limestone proper and the base of the Millstone-grit. Bands and nodules of chert also occur in the Carboniferous Limestone, and some which I have examined are filled with spicules, like those in the series above.

Yorkshire.—In the higher districts of Swaledale, Wensleydale, and Arkendale, in the north-west of Yorkshire,[1] the chert and siliceous rocks, composed of Sponge remains, are well-known and persistent portions of the Yoredale series, and from the fact that in common with the associated limestone and other rocks they are traversed in places by veins of lead-ore which have been largely worked, the various beds have been recognised by distinctive names. Thus the upper beds are known as the "Red-Beds Chert," and below these and separated from them and from each other by intervening beds of limestone, shale, and sandstone, are the "Black-Beds Chert," the "Main Chert," and the "Undersett Chert." The thickness of these different chert-beds varies in different sections.

The "Undersett Chert" exposed in the bed of the Swale, both below and above Keld, appears to be from 15 to 20 feet (4·5 to 6 m.) in thickness. It is here a dark, compact, brittle chert. In a railway-cutting near Leyburn, in Wensleydale, the "Undersett" is 10 feet (3 m.) in thickness. The chert here is greyish, distinctly banded, and filled with spicules. The "Main Chert" is well shown at Arkendale, on the south side of the valley; in the upper portion of Gunnerside Gill, in Swaledale; east of Leyburn in Wensleydale, as well as other places in the district. It more frequently consists of a compact, dark grey mottled, siliceous rock, rather than a true chert. The beds are continuous, with a total thickness of about 18 feet (5·4 m.). The "Black Beds" and "Red Beds Chert" are not so well exposed as the beds beneath them, but according to

[1] For much of the information respecting the distribution and the best exposures of the cherty rocks in this area I am indebted to Mr. J. G. Goodchild, F.G.S., of the Geological Survey.

Prof. Phillips[1] the thickness of these two upper series of beds in Arkendale and Swaledale varies between 36 and 54 feet (10·8—16·2 m.).

Lower down the Swale valley, and more particularly at Richmond (Yorkshire), chert-beds of the same character are frequently exposed. In quarries above Richmond there are numerous thin beds of chert and siliceous rock alternating with crinoidal limestones, probably forming part of the "Red Beds." In the section exposed, 34 feet in thickness, there are in all $9\frac{1}{2}$ feet of the siliceous rocks or Sponge-beds, which are filled with well-preserved spicules.

Judging from the data given by Prof. Phillips, and from my own observation, I should estimate that the Sponge-beds of Swaledale and Yoredale reach a total thickness of between 70 and 90 feet (21—27 m.).

In a quarry near Harrogate, in the so-called "Road-Stone," there are two beds of chert with a thickness together of two feet. The spicules are well shown in these beds.

Lancashire.—Thin bands and patches of dark chert filled with spicules are present in the Carboniferous Limestone exposed in the quarries near Clitheroe, and thin bands of siliceous shale between the beds of limestone contain detached spicules of *Hyalostelia*, *Geodites*, and *Reniera*.

North Wales.—In Flintshire there is a continuous series of chert-beds, which, as shown by the borings of the lead-mines, reach the extraordinary thickness of 350 feet[2] (105 m.). The beds are best exposed at Halkin and Henblas, near Holywell, and also at Trelogan and Gronant, near Prestatyn. They occur at the same geological horizon as the Sponge-beds of the Yoredale series in Yorkshire, that is, between the Carboniferous Limestone proper and the true Millstone-grit; but on the alleged grounds of a gradual lithological passage between the chert-beds and veritable Millstone-grit,[3] Mr. J. A. Strahan, F.G.S., who has lately surveyed the district, has included them as part of this latter division; whilst Mr. G. H. Morton, F.G.S.,[4] regards them as Carboniferous Sandstone. Neither of these geologists recognised the organic nature of the rock. Mr. Strahan has described the chert as "probably a siliceous sediment of extreme fineness," and Mr. Morton regards the strata as originally of sandstone, which has been, for the most part, converted into chert.

Microscopic sections of the chert collected from the different outcrops show the presence of the same spicules as in the Yorkshire beds, and that this remarkable series of chert rocks are built up of the integrated skeletons of siliceous Sponges. As a rule, the spicules in these Flintshire cherts are not so favorably preserved

[1] 'Geology of Yorkshire,' part ii, p. 66.

[2] 'Mem. of the Geol. Survey, Explanation of Quarter-Sheet 79 N.-W.,' p. 18.

[3] Op. cit., p. 18.

[4] 'Proc. Liverpool Geol. Soc.,' vol. iv, pt. v, 1882-3, p. 393.

as those of the Yorkshire beds, but the same forms of *Hyalostelia* and *Reniera* can be recognised in them.

At the head of the Gwydfyd Valley, on the Great Orme's Head, there are portions of broken-up beds of white and bluish cherty rocks, which have been described by Mr. George Maw, F.L.S.,[1] and estimated by him to be about 50 feet in thickness. They apparently belong to the series above the Carboniferous Limestone; the fragments are filled with spicules, principally minute acerates, similar to those in the beds at Gronant.

Scotland.—The beds which have yielded the remarkable series of Sponge remains in Ayrshire, belong to what is known as the Upper-Limestone and Lower-Limestone series of the Scotch geologists, which are situated beneath the Millstone-grit, and thus on the horizon corresponding to the Yoredale series of Yorkshire and North Wales, in which Sponge-beds are so largely developed.

In Ayrshire, however, the Sponge-remains[2] have principally been obtained from decayed material in the joints and fissures in the limestone, and in soft, siliceous clays infilling irregular cavities in the same rock. Mr. John Smith, of Kilwinning, has supplied me with the following list of localities in Ayrshire which have yielded Sponge-spicules; Stacklawhill, thirty feet above the Linn-Spout Limestone; Glencart, Lambridden, Linn Spout, and Monkcastle, in the Upper-Limestone series; Birkhead, Thirdpart, Blackstones, Cunningham Baidland, Low Baidland, Law, and Auchenskeith, in the upper part of the Lower-Limestone series; and Crawfield in the lower part of the same series. Other localities are Dockra, Hillhead, near Beith, and Dunlop, Ayrshire. They have also been met with in the limestones at Corrieburn, Campsie Hills, near Kirkcaldy, Fifeshire, near Linlithgow, Charlestown Quarry near Inverkeithing, Roscobie Quarry, near Dunfermline, Macbiehil, Peebles, near Cupar, and near Dalkeith. The forms most widely distributed are the anchoring spicules of *Hyalostelia* and the cylindrical spicules of *Reniera;* in the Ayrshire district these are accompanied by the remarkably large spicules of *Geodites*, *Asteractinella*, *Tholiasterella*, and *Acanthactinella*. Though the beds of Sponge remains in Scotland are of much less thickness than those of Yorkshire and North Wales, yet, owing to the preservation of the spicules in loose materials, they have yielded a greater number of species.

Ireland.—A well-marked series of Sponge-beds, hardly inferior in importance to those of Yorkshire and North Wales, is developed in the so-called Upper Limestone of the Carboniferous series of the Irish Geological Survey. The Sponge-beds principally occur in the higher portions of the Upper Limestone, and they have been included with this as the equivalents of the Carboniferous or Mountain Lime-

[1] 'Geol. Mag.,' vol. ii, 1865, p. 200.

[2] 'Catalogue of the Western-Scottish Fossils,' 1876, p. 36; also 'Proc. Nat. Hist. Soc. Glasgow,' 1882, p. 234.

stone of England, whilst the overlying shales and sandstones between them and the Millstone-grit are regarded by Prof. Hull[1] as corresponding to the Yoredale-beds. As, however, the Sponge-beds consist of chert, closely resembling that of the Yoredale series in England and North Wales, it is reasonable to conclude that they may occupy a corresponding horizon, even though no well-marked line of demarcation between them and the main mass of the Carboniferous Limestone has up to the present been noted.

The Sponge-beds chiefly occur as nodular masses or bands of dark, mottled, compact chert, closely similar to those of Yorkshire and North Wales.[2] Microscopic sections of specimens which I have lately collected from various outcrops of the rock in Queen's County and Kilkenny to the south, and in Fermanagh and Sligo to the north-west of Ireland, all show the presence of spicules, and distinctly prove that the rock has been derived from them.

Well-marked beds of chert, from one to three inches in thickness (·025—·075 m.), are also frequently present in the dark limestones of the Calp or Middle series of the Carboniferous Limestone in the neighbourhood of Dublin, and these, like the higher beds, are filled with microscopic spicules.

Owing to the irregular manner in which the nodular masses and bands of chert, constituting the Sponge-beds, are intercalated in the limestones of the Upper Series in Ireland, it is difficult to form an estimate of their total thickness. In Queen's County and Kildare the chert layers are stated[3] by the late Professor Jukes and Mr. Kinahan to be sometimes so frequent that they make the rock nearly an entire mass of chert. In the ridge west of Carlow the greyish chert is stated to be over 30 or 40 feet in thickness.[4] At Florence Court, near Enniskillen, Professor Hull[5] estimates that the chert bands in the Upper Limestones have a total thickness of perhaps 150 feet (45 m.); but from my own observation this estimate seems considerably too high.

[1] 'Scientific Trans. Roy. Dublin Soc.,' vol. i, N. S., 1878, p. 73.

[2] In a recently published paper ('Proc. Royal Soc.,' vol. xlii, 1887, pp. 304—308) Prof. Hull, F.R.S., the Director of the Irish Geological Survey, most emphatically combated a suggestion made by me two years since, that the chert bands of the Irish Carboniferous Limestone were probably derived from Sponge-spicules, the same as the chert beds of the Cretaceous strata of the south of England ('Phil. Trans.,' 1885, pt. ii, p. 433).

After the publication of this paper I went to Ireland and examined the chert beds in the various localities from whence Prof. Hull had obtained the specimens on which he based his conclusions, and I then found that there was decisive evidence that they were derived from Sponge remains as I had suggested ('Geol. Mag.,' n. s., dec. iii, vol. iv, p. 44). An inspection of the microscopic sections which Prof. Hull described and figured showed, as Prof. Sollas had already stated ('Ann. and Mag. Nat. Hist.,' vol. vii, 1881, p. 141), that some of them were largely composed of spicules.

[3] 'Geol. Surv. Ireland, Explanation Sheet 128,' p. 12, also quoted by Prof. Hull, op. cit., p. 75.

[4] 'Scientific Trans. Roy. Dublin Soc.,' vol. i, N. S., 1878, p. 75.

[5] 'Proc. Royal Soc.,' vol. xlii, p. 306, Note.

The chert beds are well developed in the Upper-Limestone series of the County of Sligo ; more especially at the hill of Keishcorran near Ballymote, on the higher slopes of Knock-na-Rea, near the town of Sligo, and in the ridge of Ben Bulben to the north of Sligo Bay. The separate bands of chert vary from one to five inches in thickness, with intervening layers of blue limestone. The chert bands are frequent, and I should judge that in different places they form from one-tenth to one-fifth of the total mass of the rock. Beds of siliceous clay—probably resulting from decayed chert—and like the material in the Ayrshire deposits, filled with loose spicules, have been met with near the summit of Ben Bulben, and their contents described by Mr. H. J. Carter, F.R.S.[1]

It is evident that to produce the enormous accumulation of spicules sufficient to build up beds of rock like those referred to in Yorkshire, North Wales, and Ireland, reaching in one place a maximum thickness of 350 feet (105 m.),[2] Sponge life must have been extremely abundant and persistent in the Carboniferous epoch, more so, perhaps, than at any subsequent period. It is true that the number of species yet recognised from these thick deposits of Sponge remains is comparatively limited, but it is hardly safe to conclude from this fact that there was but little variety of form in the group at this period, for, owing to the general and complete manner in which the Sponge-skeletons have been reduced into their component elements, and their unfavorable condition of preservation, all other generic and specific characters, beyond those of the form and proportions of the individual spicules, have been obliterated. The fact that not a single example of an entire Sponge has been up to the present discovered in any of the Sponge-beds of Yorkshire, North Wales, and Ireland is a striking proof of the complete manner in which their skeletons have been broken up. In this respect fossil Sponges have undergone the same reducing process as the Crinoids, of whose remains the massive beds of limestones in the Yoredale series mainly consist. Whilst in the limestones we rarely meet with more than the disarticulated joints and plates of the stems and calyces of Crinoids, in the chert and siliceous rocks intercalated with

[1] 'Ann. and Mag. Nat. Hist.,' ser. 5, vol. vi, 1880, p. 209.

[2] Professor Sollas has lately stated that the extraordinary profusion of Sponge-spicules in modern marine deposits and in the ancient stratified rocks is due to the fact that the living Sponge is constantly producing and disengaging spicules, and that during the process of "growth the spicule slowly passes from the interior to the exterior of the sponge, and is finally, in at least some Sponges (*Geodia*, *Stelletta*), cast out as an effete product" ("Sponges," 'Encyclopædia Britannica,' ninth edition, vol. xxii, p. 420). Hitherto these deposits of Sponge remains have always been regarded as arising from the disintegration of their skeletons after the death of the Sponge, and this still seems to me the more probable explanation. Prof. Sollas' statement is so marvellous that it will require strong confirmatory evidence before it can be accepted. At present none is given, and the general experience of other observers points in an opposite direction, viz. that in the growth of the Sponge the skeletal-spicules gradually tend to become firmer and more deeply embedded in the living tissues of the organism.

the limestones only the microscopic detached skeletal-spicules of Sponges have been preserved.

Permian System.—It is doubtful whether any genuine fossil Sponges have as yet been discovered in the strata of this system in the British area; those described as such by the late Prof. King[1] prove, on examination, to be either organisms of very problematical character or inorganic concretions. The forms described as Sponges by Prof. Geinitz[2] from the corresponding Dyas of Germany, are of an equally dubious character.

[1] 'Monog. of the Permian Fossils,' Pal. Soc., 1849, pp. 11—14.

[2] 'Die animalischen Ueberreste der Dyas,' 1861, pp. 123-4, pl. xx.

DESCRIPTION OF GENERA AND SPECIES.

CAMBRIAN SPONGES.

Sub-Order.—HEXACTINELLIDÆ.

Family.—PROTOSPONGIDÆ.

Genus.—PROTOSPONGIA, *Salter.*

1864. 'Quart. Journ. Geol. Soc.,' vol. xx, p. 238.

Generic Characters.—Sponges probably cup- or vase-shaped, with walls consisting apparently of a single layer of spicular mesh. This is composed of cruciform spicules of varying dimensions; the larger are arranged so as to form a regular quadrate framework, which is divided into secondary squares by smaller spicules, and these are again subdivided in a similar manner, so that, when complete, there are four or five series of squares. The spicular rays appear to have been organically cemented together at their points of junction with each other, and there are traces of a delicate membrane in the interstitial areas between the rays, which may have united the entire meshwork together.

No other structures beyond the wall of spicular framework have as yet been discovered, and it may be presumed that this constituted the entire skeleton of the Sponge.

This genus is, apparently, most nearly related to *Dictyophyton*, Hall, in which the Sponge-wall is similarly constituted of larger and subordinate squares; but hitherto the spicular structure of these squares has not been described, and it is quite possible that it may not have been of cruciform spicules like those of *Protospongia*. From *Phormosella*, Hinde, the present genus is distinguished by the regular arrangement of the larger and smaller squares of the meshwork, and from *Plectoderma*, Hinde, by the simple, nonfasciculate disposition of the spicules.

Mr. Salter defined the skeleton of this genus as "loosely reticular, formed of very large cruciform spiculæ, the branches of which cross each other at an angle of 80°, and only in one plane, no ascending or descending branches rising from the

point of conjunction." This view of the spicular character of the skeleton was much nearer the truth than that of Dr. Bowerbank, who stated that the structures were not spicules, but horny fibres replaced by pyrites.[1]

Different opinions are held as to whether the spicules in this genus were free, and merely held in position by the soft structures of the animal, or whether they were organically attached together by a deposition of silica at the junction of the rays with each other. So far as I have been able to judge from the few instances in which the spicular rays are seen in contact, they appear to have been cemented or fused together at their junction with each other, though there is not that complete coalescence of the adjacent rays which exists in regular Dictyonine hexactinellids. The spicular rays do not interlace with each other sufficiently to account for the preservation of connected portions of the meshwork in the fossil state, and without a certain degree of organic attachment they would, almost inevitably, have fallen entirely apart from each other. The fusion of the rays at their points of contact does not, however, appear to have been sufficiently strong to prevent that partial disruption of the spicular wall which has taken place in most of the examples, or the isolation of the larger spicules in many cases.

1. Protospongia fenestrata, *Salter*. Pl. I, figs. 1, 1 *a*.

1864.	Protospongia	fenestrata,	*Salter*.	Quart. Journ. Geol. Soc., vol. xx, p. 238, pl. xiii, figs. 12 *a*, *b*.
1873.	—	—	—	Cat. Cambrian and Sil. Foss. Cambridge, p. 3.
1877.	—	—	*Zittel*.	Studien, Ab. 1, p. 45; Königl. bayer. Akad. der Wiss., Cl. ii, Bd. xiii, Ab. 1; Neues Jahrbuch, p. 354.
1877.	—	—	*Carter*.	Ann. and Mag. Nat. Hist., ser. 4, vol. xx, p. 177.
1880.	—	—	*F. Roemer* (in part).	Lethæa palæozoica, Th. 1, p. 316, fig. 59 *a*.
1881.	—	—	*Etheridge, senr*.	Mem. Geol. Surv., vol. iii, 2nd ed., Appendix, p. 472.
1882.	—	—	*Zittel*.	Neues Jahrb., Bd. ii, p. 203.
1883.	—	—	*Hinde*.	Catalogue Foss. Sponges, p. 129, pl. xxviii, fig. 2.

The fragments of the wall of this species which have been preserved are insufficient to indicate the probable form of the Sponge. The cruciform spicules

[1] 'Quart. Journ. Geol. Soc.,' vol. xx, p. 239.

forming the skeletal mesh are of a delicate character, the rays are circular in section and nearly of an even thickness throughout their length. It is probable that the spicules were originally rectangular, but in the type specimen the rays are now oblique, owing to the distortion produced by the compression of the rock matrix. There are five different series of squares in the Sponge-wall, the rays bounding the largest squares are 8 mm. in length by ·2 mm. in thickness, whilst the rays forming the secondary and smaller squares are 4 mm., 2, 1, and ·5 mm. in length respectively. The junction of the rays with each other is, in no case, distinctly shown; they can be traced nearly to the point of contact, and do not apparently overlap the squares in which they are situated.

The typical example of this species, now in the British Museum, exhibits a fragment of the Sponge-wall on the surface of a slab of hard black shale. The original silica of the spicules has been replaced by iron-pyrites, and a delicate film of this mineral extends over the surface of the Sponge, and is probably a replacement of a siliceous dermal membrane, which served in part to hold the spicular mesh together. Not only is the spicular framework distorted, but in all the specimens I have seen it is partially broken up and many of the spicules absent or displaced.

This species differs from *Protospongia Hicksi* in the much more slender character of the spicular mesh, which is very clearly shown in the figures of the two species on Plate I.

Distribution.—Cambrian: Menevian Group, St. David's, South Wales; Lower Lingula Beds, Tyddyngwladis, Upper Mawddach, North Wales.

2. Protospongia Hicksi, *Hinde sp. nov.* Pl. I, figs. 2, 2 *a*.

1871. Protospongia fenestrata, *Hicks.* Quart. Journ. Geol. Soc., vol. xxvii, p. 401, pl. xvi, fig. 20.
1878. — — *Brögger.* Om paradoxidesskifrene ved Krekling, Nyt. Mag. f. Naturvidensk., vol. xxiv, p. 36, pl. vi, fig. 14.
1880. — — *F. Roemer* (in part). Lethæa palæozoica, Th. 1, p. 316, fig. 59 *b*.
1880. — — *Sollas.* Quart. Journ. Geol. Soc., vol. xxxvi, p. 362, fig. 1.
1884. — — *Walcott.* Pal. of the Eureka District, United States Geol. Surv., vol. viii, p. 10, pl. ix, figs. 5 *a*, *b*.

Sponge probably vasiform; the portions preserved indicate that the type specimen was at least 100 mm. in height by 75 mm. in width at the summit. The

spicular mesh is composed of robust cruciform spicules, the rays are approximately rectangular, and nearly of a uniform thickness throughout their length. The centres of the spicules are slightly elevated, so that they are not strictly horizontal. The rays of the smaller spicules in the majority of cases dip beneath those of the larger forms. Five series of squares are present in the complete mesh, the largest are 8 mm. in diameter and the smallest ·5 mm.; the axes of the largest spicules are 16 mm. in length and ·52 mm. in thickness, whilst the smallest are 1 mm. in length and ·2 mm. in thickness.

The typical example of this species, now in the Woodwardian Museum at Cambridge, is preserved on a block of black slate. The spicular mesh has been replaced by iron-pyrites; in places it stands boldly out from the rock surface. Though the regular arrangement of the spicules of the mesh is clearly shown in only one portion of the specimen, it can be traced over an extended surface, and it occurs at two different levels separated by an interval of matrix, of about 4 mm. in thickness. This appears to me to indicate that the entire Sponge was vasiform or cup-shaped, and that, owing to pressure, the opposite walls of the cup are now nearly in contact with each other.

The original specimen was discovered by Dr. H. Hicks, F.R.S., who referred it to *P. fenestrata*, Salter. It was subsequently described in considerable detail by Prof. Sollas, who also regarded it as identical with Salter's species. A comparison of this form with the type of *P. fenestrata* shows, however, a very considerable difference in the thickness of the spicular rays, sufficient to indicate it as a distinct species, which I have named in honour of its discoverer.

In no case in this specimen are the points of contact of the spicules with each other clearly shown, but the structure of the mesh appears to me to justify the view that the spicules are cemented together where they join each other; Prof. Sollas states, however, that they are separated and not united either by envelopment in a common coating or by ankylosis.

Fragments of mesh and detached cruciform spicules, apparently belonging to this species, have been discovered in Norway, Sweden, and also in Nevada, at approximately the same geological horizon.

Distribution.—Cambrian; Menevian Group. Porth-y-Rhaw, near St. David's, South Wales. Cambrian; Paradoxides-Shales, Krekling, Norway (Brögger); at Andrarum, Sweden, in beds with *Paradoxides* and *Agnostus pisiformis;* Eureka district, Nevada, in the Prospect Mountain Group (Walcott).

Group.—LYSSAKINA.

Family.—POLLAKIDÆ.

Genus.—HYALOSTELIA, *Zittel*; Emend. Hinde.

1878. Handbuch der Palæontologie, Bd. i, Lief. 2, p. 185.

Syn.—Pyritonema, *M'Coy;* Acestra, *F. Roemer;* Acanthospongia, *Young* (non *M'Coy*); Hyalonema, *Young, Carter* (in part); Serpula, *Portlock, M'Coy* (in part); Astroconia? *Sollas.*

Generic Characters.—Complete form of Sponge unknown; the body-portion is composed partly of simple hexactinellid spicules in which one axis is usually much elongated, and partly of spicules in which one or more of the rays are inflated, spined, reduced to rounded knobs, or even absent. The dermal layer is mainly formed of large spicules in which the distal ray is reduced to a blunted process. The anchoring appendage consists of elongated, cylindrical, rod-like spicules, which are either separate, or in rope-like bundles, and sometimes terminate in four recurved rays.

This genus was based by Prof. Zittel on the characters of *Hyalonema Smithii*, as described by Messrs. Young and Young.[1] These authors, however, included in the type-species a great variety of forms of detached spicules, some of which belong to distinct genera. Thus, for example, the spicules with from six to eight horizontal rays, mentioned in Zittel's diagnosis of the genus, do not belong to the same Sponge as the simple hexactinellid spicules. This has been proved by the subsequent discovery of fragments of spicular mesh, in some of which hexactinellid spicules and their modifications are exclusively present, whilst others are composed only of the umbrella-shaped spicules with numerous horizontal rays.[2] I have therefore proposed that the skeletal-spicules in *Hyalostelia Smithii*, which has been taken as the type of the genus, should be restricted to such simple and modified hexactinellids as are present in the connected fragments of skeleton, and that the umbrella- and stellate-spicules should be excluded from it. The body-spicules do not appear to have been originally attached together in any way; those occurring in the fragments of the skeleton which have been met with are held together by a secondary deposit of silica.

The elongated anchoring spicules of the Sponge are present in great abundance in the same beds with the body-spicules, and are therefore assumed to have

[1] 'Ann. and Mag. Nat. Hist.,' ser. 4, vol. xx, p. 425, pls. xiv, xv.

[2] 'Cat. Foss. Sponges,' p. 150.

belonged to the same Sponge. In some instances, however, the spicular ropes and detached spicules occur in beds in which no hexactinellid spicules have as yet been met with; but this may in part be accounted for by the fact that even during the life of the Sponge the anchoring spicules would be buried in the bottom ooze, and would thus escape the disturbing influences which have probably scattered and destroyed the body-spicules after the death of the Sponge.

These anchoring spicules, in the best preserved examples, exhibit all the characters of similar spicules in recent hexactinellid Sponges met with in deep-sea dredgings. They are composed of silica deposited in concentric layers, they are traversed by an axial canal, and many of them likewise terminate in four recurved hooks. Further, in one species the surface of many of these spicules is ornamented with slight projecting frills of a character similar to those present in the anchoring spicules of the recent *Hyalonema mirabile*, Gray. As the recent anchoring spicules are in all cases associated with a Sponge body consisting of hexactinellid spicules, it may be concluded that the fossil anchoring spicules were similarly associated, even though they now occur in beds in which the hexactinellid body-spicules are rare or apparently absent.

Pyritonema, M'Coy, and *Acestra*, F. Roemer, have been founded exclusively on the bundles of anchoring spicules. On the ground of priority, M'Coy's term might be claimed as the designation of this genus, but as objection could be taken to employing it for hexactinellid body-spicules as well as for the anchoring spicules, it seems preferable to adopt Zittel's name *Hyalostelia*, which includes both kinds of spicules.

Both M'Coy and Portlock regarded the anchoring spicules occurring in the Carboniferous Limestone of Ireland as the tubes of annelids, and placed them in the genus *Serpula*.

Hyalostelia is first known in Cambrian strata (Tremadoc Group), and it is also present in Ordovician, Silurian, and Lower-Carboniferous Rocks. Detached hexactinellid spicules in the Upper Chalk have been assigned to the genus, but the ropes or bands of anchoring spicules have not been met with above the Carboniferous Rocks.

3. Hyalostelia fasciculus, *M'Coy* sp. Plate I, figs. 3, 3 *a*, 3 *b*.

1850. Pyritonema fasciculus, *M'Coy*. Ann. and Mag. Nat. Hist., ser. ii, vol. vi, p. 273.
1854. — — *Morris*. Cat. Brit. Foss., p. 63.
1855. — — *M'Coy*. Brit. Pal. Foss., p. 10, pl. i B, fig. 13.
1869. Eophyton explanatum, *Hicks*. Geol. Mag., vol. vi, p. 534, pl. xx, figs. 1 *a—e*.

1873.	PYRITONEMA FASCICULUS, *Salter.*	Cat. Cambrian and Silur. Foss. Cambridge, p. 30.
1881.	EOPHYTON ? EXPLANATUM, *Nathorst.*	Om spår af nagra evertebrade djûr, &c., Kong. Svenska vetensk. Akad. Handl., Bd. 18, No. 7, p. 46.
1881.	— — *Hicks.*	Quart. Journ. Geol. Soc., vol. xxxvii, p. 490.
1883.	HYALOSTELIA FASCICULUS, *Hinde.*	Cat. Foss. Sponges, p. 151.
1886.	— — —	Geol. Mag., dec. iii, vol. iii, p. 337, fig. 1.

No hexactinellid body-spicules are as yet known in connection with this species, which is founded exclusively upon fragments of the bundles of spicular rods forming the anchoring appendages of the Sponge. In some examples the bundles occur as narrow, nearly straight bands of indefinite length; the longest specimen known is 140 mm. in length, from 5 to 6 mm. in width, and with a thickness varying from ·5 to 2 mm.; in others they resemble stout ropes, from 20 to 25 mm. in thickness. The individual rods composing these bundles are, for the most part, in close contact and parallel with each other, and there is no apparent twist in their course. Their axial canals are but rarely preserved, and the natural termination of the spicules is unknown. They are nearly circular in transverse section, and vary from ·15 to ·7 mm. in thickness. The surface of some of these spicular rods is quite smooth, whilst in others there is a minute projecting frill, disposed in an annular or spiral form, so that the spicule appears to be covered with transverse, slightly wrinkled striæ. The spicular rods also occur detached and scattered through the rock, crossing each other in various directions.

This species was founded by Prof. M'Coy on a fragmentary band of spicules embedded in dark limestone of Llandeilo age. Special mention is made in the description of the irregular transverse plicæ on the surface of the spicules, or tubes, as they are termed; and this structure is clearly shown in the accompanying figure pl. i B, fig. 13 *a*. In the original specimen, however, now preserved in the Woodwardian Museum, Cambridge, the "plicæ" are very indistinct, and they can scarcely be distinguished from fractures in the spicules. In other specimens from Llandeilo rocks, the transverse frills are very prominent, and they form one of the distinguishing characters of the species. In some bundles, nearly all the spicules are frilled, but in others, only one in ten, or one in twenty are thus ornamented, whilst the others are quite smooth. In the anchoring rope of the recent *Hyalonema*, Gray, some of the spicules are likewise furnished with spiral frills,[1] bearing minute spines, thus showing a general correspondence in structure to these Cambrian forms.

Slight differences exist in the maximum thickness of the spicular rods in different bundles; for, whilst in some the largest spicules do not exceed ·5 mm. in

[1] Carter, 'Ann. and Mag. Nat. Hist.,' ser. 4, vol. xii (1873), p. 372, pl. xiv.

thickness, in others they reach to ·7 mm. In every instance smaller spicules are intermingled in the same bundles with the larger. In all the specimens examined the spicules are composed of chalcedonic silica.

The larger bundles, which are not infrequent in the Llandeilo strata of Pont Ladies, are usually curved and folded over in various ways, which appear to result from the compressing and folding of the rocks in which they are enclosed.

M'Coy correctly compared this species with the anchoring rope of the recent *Hyalonema*, which at that time was regarded as a zoophyte, and it is placed in Morris's catalogue with the Gorgonidæ. The specimen discovered by Dr. Hicks in the Tremadoc strata of St. David's, was originally described by him as a vascular cryptogam under the name of *Eophyton? explanatum;* its true nature appears to have been first noticed by Dr. Nathorst, who pointed out its similarity to M'Coy's species.

In the size of the spicules forming the bundles the present species corresponds very closely with *Hyalostelia parallela*, M'Coy sp., from the Carboniferous strata of Ireland, but transverse striæ are not developed in any of the spicules of this latter form.

Distribution.—Cambrian: Tremadoc strata, St. David's (Dr. Hicks). Ordovician: Llandeilo, Tre Gil, south of Llandeilo (M'Coy); Meadowtown, Pont Ladies, Mincop, Shelve, Shropshire (Mr. G. H. Morton); near Builth? (Wyatt-Edgell Coll. in Geol. Surv. Museum); Dobb's Linn, Moffat (Prof. Dr. H. A. Nicholson).

ORDOVICIAN SPONGES.

Sub-Order.—LITHISTIDÆ.

Family.—ANOMOCLADINA.

Genus.—ASTYLOSPONGIA, *F. Roemer.*

1860. Die silurische Fauna des westlichen Tennessee, p. 5.

Syn.—Siphonia, in part *Goldfuss; Hisinger.*

Generic Characters.—Sponges sub-spherical or ovate in form, simple, free, with rounded bases, in which there is no indication of any surface of attachment. Two systems of canals are present, one extending from the outer surface towards the centre of the Sponge, and the other of large canals which have a generally vertical direction, following the outlines of the Sponge, and opening either into a shallow

cloacal depression or freely at the summit. The spicular structure is a firm resistant mesh-work composed of spicules with solid rounded nodes or centres, from which from six to nine straight arms radiate in different directions. The spicular rays terminate in branched and slightly expanded processes, which are closely apposed to the nodes of adjoining spicules to form the skeletal meshwork; in some cases, also, the rays meet where no centres exist, and their extremities partially interlock together and form a pseudo-node by their union.

The Sponges of this genus were originally regarded as belonging to the genus *Siphonia*,[1] and as having been derived from Cretaceous strata. A similarity in their canal-structures to those of true *Siphoniæ* supported this belief, and their actual occurrence in the Drift deposits of Northern Germany mingled with Chalk Sponges was accepted as a confirmation of their coexistence in the Cretaceous strata. The subsequent discovery by F. Roemer[2] of the same forms in unquestionably Silurian strata in North America led to a recognition of their true position. They were then placed, both by Zittel[3] and by Roemer, with the Hexactinellidæ,[4] from the supposed six-rayed character of the spicules; but after that Dr. R. Martin[5] had pointed out the variable number of the rays in the spicules, Zittel[6] removed the genus to the Anomocladina family of the Lithistidæ, to which it is naturally allied both in general form, in its canal-systems and its spicular structure. Zittel, however, now regards the elementary spicules of the genus as simple rods with branching extremities, which by their union together form the nodes. There is some difficulty in determining the character of the elementary spicules, since in no instance at present have they been found detached, whilst in the connected skeletal mesh the union is so intimate that their elementary characters are concealed. In the recent[7] *Vetulina stalactites*, Os. Schmidt, which has been placed by Zittel in the same family as *Astylospongia*, the elementary spicules clearly consist of rays projecting from central nodes, and there is reason to conclude that the spicular elements of *Astylospongia* were similarly constituted.

The species of this genus are limited to Ordovician and Silurian strata, principally the latter. They are comparatively abundant in North America and in the Silurian districts of the Baltic, but with the single exception of the form mentioned below from Caradoc strata, the genus is not otherwise represented in this country.

1 'Petref. Germ.,' vol. i, p. 17.

2 'Die silurische Fauna d. westl. Tenn.,' p. 5.

3 'Studien I,' p. 44.

4 'Lethæa pal.,' p. 307.

5 "Untersuchung über die Organisation von *Astylospongia*," 'Archiv des Ver. d. Freunde d. Naturgesch. in Mecklenburg,' Jahrg., xxxi, 1877.

6 "Ueber Astylospongidæ und Anomocladina," 'Neues Jahrb.,' 1884, Bd. ii, p. 75.

7 See Sollas, "On *Vetulina stalactites*" (O. S.), 'Proc. Roy. Irish Acad.,' 2 ser., vol. iv, p. 486.

4. Astylospongia inciso-lobata, *F. Roemer*. Plate II, figs. 5, 5 *a*.

1860.	Astylospongia	inciso-lobata,	*F. Roemer*.	Die silur. Fauna d. westl. Tenn., p. 11, pl. i, figs. 3, 3*a*.
1848.	Spongia	—	—	Leonh. u. Bronn's Jahrb., p. 685.
1861.	Astylospongia	—	—	Die fossile Fauna von Sadewitz, p. 13, pl. ii, fig. 4.
1864.	—	—	*Salter*.	Quart. Journ. Geol. Soc., vol. xx, p. 239, Note.
1873.	—	grata,	— M.S.	Cat. Cambrian and Silur. Foss. Cambridge, p. 31.
1880.	—	inciso-lobata,	*F. Roemer*.	Lethæa pal., p. 310.

Sponges depressed spherical in form, with shallow furrows extending down the sides so as to form imperfect lobes. The canals open freely at the summit of the Sponge.

The only British example of this species, now preserved in the Museum of the Geological Survey, Jermyn Street, is 16 mm. in height by 36 mm. in transverse diameter. The summit is slightly convex, and the canal-apertures, about 1 mm. in width, are irregularly disposed over it. Six shallow furrows, indicating as many lobes, extend from near the summit to the base. The interior of the specimen is now a solid mass of iron-pyrites, in which only traces of canals can be distinguished, and, as the spicular structure is altogether obliterated, its true character is not altogether free from doubt. The specimen was originally referred to *A. inciso-lobata* by Mr. Salter, but subsequently, in the catalogue of the Cambrian and Silurian fossils at Cambridge, he named it *A. grata*, MS., without, however, adding any description. As from the condition of the specimen no other feature beyond the outer form is available for comparison, it seems preferable to place it in the present species, which is distinguished by similar lobate outlines.

Distribution.—Ordovician: Caradoc Shale, Haverford-west, South Wales. It also occurs in Silurian strata in West Tennessee, and in Glacial Drift at Sadewitz, Lower Silesia (F. Roemer.)

Genus.—Hindia, *Duncan.*

1879. Ann. and Mag. Nat. Hist., ser. 5, vol. iv, p. 84.

Syn.—Calamopora, *F. Roemer* (non Goldfuss), *Steinmann ;* Sphærolites, *Hinde.*

Sponges spherical or sub-spherical in form, free, without stem or any surface of attachment. The body of the Sponge is traversed throughout by straight, simple, subcylindrical or prismatic, sub-equal canals, radiating, in close proximity to each other, from a central space, and opening freely at the surface. The skeleton consists of spicules generally with four rays (though occasionally only three are developed) which extend from a compressed central node. Three of the rays are sub-equal, whilst the fourth is truncated. The rays terminate in flattened, circular, irregularly digitate expansions, which firmly clasp the nodes and convex surfaces of the rays of adjoining spicules in such a manner as to form an extremely regular meshwork, with transversely elliptical interspaces.

Specimens of this genus from West Tennessee were originally described as corals by F. Roemer[1] under the name of *Calamopora fibrosa.* They occur as silicified casts, in which the original structure has been entirely removed; and in this condition they resemble very closely small silicified corals. Without being aware of F. Roemer's reference of the forms to corals, I made a similar mistake respecting forms which I had collected from New Brunswick, erroneously regarding them as perforate corals, which I named *Sphærolites.*[2] My specimens were afterwards submitted to Prof. M. Duncan,[3] who recognised the spicular nature of this skeleton, and constituted them into a new genus of Sponges, which he named *Hindia.* The original silica in these specimens had been replaced by calcite, but Prof. Duncan, maintaining that the skeletons were originally of calcite, principally on the ground of the supposed presence in them of a parasitic Alga, regards the forms as Calcisponges, representing a former mimetic and calcareous group of Spongida. Their general structure corresponds so closely with that of Lithistid Sponges that I felt justified in placing the genus in the Anomocladina family of this group;[4] Zittel,[5] however, regarded the genus as more properly coming within the Megamorina family. A later writer,[6] Dr. Steinmann, has asserted that the genus exhibits none of the characters of Lithistid Sponges, and that it really

1 'Die silur. Fauna d. westl. Tenn.,' p. 20.

2 'Abstract Proceedings Geol. Soc.,' 1875, No. 305.

3 'Ann. and Mag. Nat. Hist.,' ser. 5, vol. iv, p. 84, 1879.

4 'Cat. Brit. Foss. Spong.,' p. 57, 1883.

5 'Neues Jahrb.,' 1884, Bd. ii, p. 79.

6 Ibid., 1886, Bd. i, Heft i, p. 91.

belongs to perforate corals like *Favosites.* In reply to this, Dr. H. Rauff[1] showed more clearly than had been done by previous writers the spicular characters and the structure of the genus, which, however, he placed in the Tetracladina family of Lithistids. Prof. Duncan,[2] still relying on the supposed parasitic borings in the Sponge, has reasserted that it was an originally calcareous organism. Whatever may be the nature of the bodies which Prof. Duncan refers to Algæ, it is evident, from the fact that they are present in the siliceous matrix of the Sponge, and apparently do not penetrate the spicules themselves, that they have no bearing on the original mineral constitution of the Sponge itself. The specimens, in which the skeleton is now of carbonate of lime, present the same evidence that this mineral is a replacement of silica, as the calcified examples of *Astylospongia* and other Lithistid Sponges from the Silurian strata, and there is but little doubt that as in these forms the original spicular structure of *Hindia* was siliceous.

The character of the spicules, consisting of a central node with diverging rays, and their mode of union to form the skeleton by the clasping of their expanded extremities to the nodes of adjoining spicules, appear to me to indicate their position in the Anomocladina family.

Hindia makes its first appearance in Ordovician strata in Ayrshire and in Illinois; it is more abundant in Silurian strata in various places in North America, Russia, Isle of Gothland, Sweden, and in the Drift deposits of Northern Germany. Detached spicules, referable to the genus, are also present in the Carboniferous Limestone of Sligo, Ireland, and the Yoredale Beds of Yorkshire.

5. Hindia fibrosa, *F. Roemer* sp. Plate IX, figs. 3, 3 *a*—3 *e*.

1860. Calamopora fibrosa, *F. Roemer* (non *Goldfuss*). Die silur. Fauna d. westl. Tenn., p. 20, pl. ii, figs. 2, 2 *a, b.*
1861. Monticulipora petropolitana (in part), *F. Roemer.* Die fossile Fauna von Sadewitz, p. 28.
1863. Astylospongia inornata, *Hall.* Sixteenth Annual Report State Cabinet Nat. Hist., p. 69.
1875. Sphærolites Nicholsoni, *Hinde.* Abstract Proc. Geol. Soc., No. 305.
1879. Hindia sphæroidalis, *Duncan.* Ann. and Mag. Nat. Hist., ser. 5, vol. iv, p. 84, pl. ix.
1883. — fibrosa, *Hinde.* Cat. Foss. Sponges, p. 57, pl. xiii, figs. 1, 1 *a*, 1 *b*.
1884-5. — — *F. Roemer.* Lethæa erratica. Palæontolog. Abhandl., 2te Bd., Heft 5, p. 310, pl. xxvii, fig. 17.

[1] 'Sitzungsber. der niederrhein. Gesellsch. zu Bonn,' 1886.
[2] 'Ann. and Mag. Nat. Hist.,' vol. xxiii (1886), p. 226.

1886. CALAMOPORA FIBROSA, *Steinmann*. Neues Jahrb., Bd. i, Heft 1, p. 91.
1886. HINDIA — *Rauff*. Sitzungsber. der niederrhein. Gesellsch. zu Bonn, p. i, sep. copy; also in Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 169.
1886. — SPHÆROIDALIS, *Duncan*. Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 226.
1887. — FIBROSA, *Hinde*. Ann. and Mag. Nat. Hist., ser. 5, vol. xix, p. 67.
1887. — SPHÆROIDALIS, *Duncan*. Ann. and Mag. Nat. Hist., ser. 5, vol. xix, p. 260.

The Sponges vary in form from nearly perfect spheres to biconvex discs, the outer surface is usually smooth and even. They range from 13 to 45 mm. in diameter.

In the centre of the Sponge is a small round space filled by irregular spicular tissue; from the outer border of this the canals radiate to the surface. The canals vary from ·18 to ·45 mm. in width, the smaller irregularly intermingled with the larger; their apertures are for the most part oval or elliptical. The wall between the canals consists of only a single layer of spicular tissue.

In most, if not in all cases, four rays are developed in the spicules. The central node is compressed, somewhat triangular in form, and slightly curved rays are given off from each corner (Pl. IX, figs. 3 *c*, *d*, *e*). The concave surface of the rays is smooth and even, whilst the convex is dentate or covered with tubercles. Their terminations are frequently considerably expanded, transversely to the ray itself. The fourth ray projects upwards from the centre of the node. It is usually only a short stumpy process terminating in from two to four conical spurs. The spicules are so disposed in the skeleton that the fourth ray points to the surface of the Sponge, whilst each of the other three rays is closely apposed to the nodes and convex surfaces of as many different spicules. Each spicule, therefore, supports on its upper surface three rays converging to it from adjoining spicules. The junction of these rays conceals to a large extent the shortened fourth ray, so that as a rule only its terminal spurs can be seen. The spicular rays are about ·16 mm. in length, and ·05 mm. in thickness. No canals have been discovered in them.

The union of the spicules forms a closely reticulated skeleton with generally elliptical apertures, about ·12 mm. in width, which appear as so many perforations in the walls of the radial canals.

The only example of this species from British strata is a small, irregularly-shaped, nodular fragment, discovered by Prof. H. Alleyne Nicholson, in limestones of Ordovician age at Girvan, Ayrshire. The specimen appears to be incomplete, so that its entire figure is uncertain, and the spicular structure has been so completely replaced by crystalline calcite, that the individual form and the union of the

spicules cannot be recognised. Longitudinal and transverse sections, however, clearly show its affinities with the genus, and so far as can be ascertained from the condition of the specimen it belongs to the present species.

Distribution.—Ordovician: Girvan, Ayrshire (Prof. H. A. Nicholson); Trenton limestones, near Chicago (Dr. W. R. Head). Silurian: Wänge, Isle of Gothland (Prof. G. Lindström); St. Petersburg, Russia; Perry County, Tennessee (F. Roemer); Lower Helderberg Group, Dalhousie, New Brunswick; Scoharie, New York. Glacial drift: Sadewitz, Lower Silesia (F. Roemer); Lyck, East Prussia; Rombitten, West Prussia (F. Roemer); Island of Sylt, Holstein (Haas).

6. Hyalostelia Smithii, *Young and Young* sp. Plate I, figs. 4, 4 *a*.

1877. Hyalonema Smithii, *Young and Young* (in part). Ann. and Mag. Nat. Hist., vol. xx, p. 426, pl. xiv, figs. 1—3, 5—12, 14—17.

1880. — ? Girvanense, *Nicholson and Etheridge, junr.* Mon. Silur. Foss. Girvan, Fasc. ii, p. 239, pl. xix, figs. 1—1 *b*.

The references to this species and its characters will be more fully given in treating of the Carboniferous Sponges; it is introduced here to include a specimen of elongated spicular rods from Ordovician strata.

The spicular rods in the only specimen known from this horizon are not united in bundles, but they are detached and distributed irregularly at short distances from each other in the rocky matrix. They are circular in transverse section, with apparently smooth surfaces. Their length and natural terminations are unknown. They vary very considerably in thickness, the slender rods not exceeding ·15 mm. in diameter, whilst the stoutest spicules are 1·4 mm. The axial canals are occasionally preserved.

These spicules were referred by Messrs. Nicholson and Etheridge to a distinct species, principally on account of peculiar transverse bands of varying thickness, which occur at intervals in the spicules and were believed to indicate a distinct structural feature. In sections of the type specimen from which the figures on Plate I are drawn, the spicules exhibit, by polarized light, the optical characters of chalcedonic and crystalline silica, but in the banded intervals the silica has evidently been replaced by some other mineral. The replacement has been effected along minute transverse fissures in the spicules, and the same mineral has likewise been deposited in places on their outer surfaces. It seems clear, therefore, that the bands are not original, but merely secondary structures resulting from fossilization.

In their relative proportions these spicular rods agree with those forming the

anchoring-rods of *H. Smithii*, and in the absence of any other distinguishing characters they may be included in this species. The larger spicules considerably exceed in size those in *H. fasciculus*, M'Coy sp. The only examples of this species are in the cabinet of Professor C. Lapworth, F.G.S.; the microscopic section from them, which has been figured, is in the possession of the author.

Distribution.—Ordovician. In a light grey limestone at Knockgeiran, near Girvan, Ayrshire.

Family.—Receptaculitidæ.

Genus.—Ischadites, *Murchison.*

1839. Silurian System, p. 697.

Syn.—Tetragonis, *Eichwald, Gümbel* (in part), *F. Roemer* (in part), *and other authors.* Receptaculites, *Eichwald* (in part), *Schmidt, Billings* (in part), *Meek, Worthen, Hall, Whitfield, and others.* Selenoides, *D. D. Owen.*

Sponges conical, ovate, subspherical, or pyriform, with conical, sometimes slightly elevated summits, in which there is a circular perforation opening into a central cavity. The distal or summit ray of the hexactinellid spicules forming the skeleton is modified into a delicate rhomboidal plate, which rests upon the four transverse or horizontal rays, whilst the ray extending inwards at right angles to the surface gradually tapers to an acute point. The spicules are disposed so that the summit plates are nearly in contact, and form regular spiral curves, extending from the basal nucleus to the summit of the Sponge, thus presenting an appearance like the engine-turned case of a watch (Plate II, fig. 2 *a*). The transverse horizontal spicular rays overlap each other, but are not united together, and they divide the surface of the Sponge beneath the summit plates into oblong areas. (Plate II, figs. 1, 1 *a*).

Ischadites is distinguished from *Receptaculites*, Defrance, and *Acanthochonia*, Hinde, by its conical or ovate form enclosing a central cavity, and from *Sphærospongia*, Pengelly, by the rhomboidal form of its spicular plates.

In common with the allied genera of this family, *Ischadites* has till lately been placed with the Foraminifera, though by Billings and subsequently by Salter it was regarded as a Sponge.

I have[1] already given in some detail the arguments in favour of the spicular structure, and therefore Sponge-nature of this genus and its allies, which appear

[1] 'Quart. Journ. Geol. Soc.,' vol. xl, p. 827.

to me sufficient to justify placing them with Sponges notwithstanding the abnormal character of the spicules and their peculiar arrangement in the skeleton.

Ischadites makes its first appearance in Ordovician strata (Llandeilo), and continues through the Silurian, but has not been recognised above this horizon. It occurs in Wales and the West of England, Scotland, Norway, Isle of Gothland, Sweden, Baltic Provinces of Russia, and in the United States and Canada.

7. Ischadites Kœnigii, *Murchison*. Plate II, figs. 1, 1 *a*, 1 *b*.

1839. Ischadites Kœnigii, *Murchison*. Silurian System, p. 697, pl. xxvi, fig. 11.
1837. Polyparium — *Hisinger*. Lethæa Suecica, p. 115, pl. xxxvi, Supplement, fig. 2.
1842. Receptaculites Bronnii, *Eichwald*. Urwelt Russlands, Heft 2, p. 80, pl. i, fig. 9.
1852. Selenoides iowensis, *D. Dale Owen*. Geol. Surv. Wisconsin, &c., p. 587, pl. ii b, fig. 13.
1854. Receptaculites Neptuni, *Morris*. Cat. Brit. Foss., 2nd edit., p. 363.
1858. — Eichwaldi, *Schmidt*. Die Silur. Formation von Ehstland, &c., p. 232.
1860. — Bronnii, *Eichwald*. Lethæa rossica, vol. i, p. 429, pl. xxvii, figs. 2 *a*, *b*.
1860. Ischadites Eichwaldi, *Eichwald*. Lethæa rossica, vol. i, p. 436, pl. xxvii, figs. 3 *a*, *b*, *c*.
1865. Receptaculites Jonesi, *Billings*. Pal. Foss. Canada, vol. i, p. 385, fig. 363; p. 389, fig. 365.
1865. — iowensis, *Billings*. Ibid., p. 385, fig. 364.
1866. Ischadites antiquus, *Salter*. Mem. Geol. Surv. Gt. Brit., vol. iii, p. 282, fig. 4.
1867. — tessellatus, *Salter*, MS. (See Siluria, 4th ed., p. 509.)
1868. Receptaculites globularis, *Meek and Worthen*. Geol. Surv. Illinois, vol. iii, p. 301, pl. ii, figs. 2 *a*, *b*.
1868. — sp.? — — Ibid., p. 301, pl. ii, figs. 1 *a*, *b*.
1873. Ischadites Kœnigii, *Salter*. Cat. Cambrian and Silur. Foss. Cambridge, p. 100.
1875. Receptaculites Ohioensis, *Hall and Whitfield*. Geol. Surv. Ohio, Pal., vol. ii, p. 123, pl. vi, fig. 1.
1875. — subturbinatus, *Hall*. Twenty-Seventh Annual Report State Museum, Albany, pl. iii, figs. 1, 2, 3.

1875.	ISCHADITES KŒNIGII,	*Gümbel.*	Beiträge Abhandl. k. bayer. Akad. Wiss., Bd. xii, Abtheil. i, p. 43, pl. A, figs. 28, 29, 30.
1878.	—	—	*Nicholson and Etheridge, jun.* Silur. Foss. Girvan, p. 20.
1878.	—	—	*Quenstedt.* Petref. Deutschl., vol. v, p. 592.
1880.	—	—	*Zittel.* Handb. der Pal., vol. i, p. 728.
1880.	—	—	*F. Roemer.* Lethæa Pal., p. 291.
1882.	—	—	*Rupert Jones.* Cat. Foss. Foram. Brit. Mus., p. 2.
1884.	—	—	*Hinde.* Quart. Journ. Geol. Soc., vol. xl, p. 836, pl. xxxvi, figs. 1, 1 *a—o*.

Sponges depressed-conical, or ovate in form, with convex, flattened, or rarely concave bases, which are quite smooth, and do not show any indications of a stem or surface of attachment. The summits are generally truncate or evenly rounded, occasionally with a slightly-elevated neck; the central aperture is from 2 to 5 mm. in width. Small individuals are only 4 mm. in height by 6·5 mm. in greatest width, whilst large forms are 40 mm. by 45 mm.

At the basal nucleus or commencement of growth there are eight minute spicules, with diamond-shaped summit-plates, disposed in a stellate form; the spicules succeeding these gradually increase in size to the zonal region of the Sponge, and then gradually diminish again towards the summit. The spicular summit-plates in the zonal areas vary in different specimens from 2 to 4 mm. in width, whilst near the top of the Sponge surrounding the aperture they are only from ·25 to ·4 mm. wide. The four horizontal or transverse rays of the spicules as a rule slightly exceed in length the semi-diameter of the respective summit-plates, and thus overlap each other. In some cases the transverse ray, which points towards the top of the Sponge, extends beyond the summit-plate, and projects partly over the plate of the spicule next above it. The spicular rays extending inwardly towards the centre of the Sponge vary from 7 to 10 mm. in length.

The examples of this species vary considerably in size and in details of outer form, but in a large series of specimens numerous transitional forms are present, connecting the extreme variations, thus showing the untenability of the species which by different authors have been founded on these individual differences.

The specimens from British strata are so altered by fossilization, that it would be impossible from them alone to understand the original structures. Even their outer forms have been considerably compressed and distorted so as to appear as merely flattened plates or thin discs, or even as surface impressions only. The summit aperture is usually concealed, and the base of the Sponge is scarcely distinguishable from the top. The spicular structures are now only represented by negative casts in the rock-matrix. Generally the surface of these specimens is

marked out by delicate curved ridges, which cross each other with great regularity, and thus form rhomboidal, slightly depressed areas, which represent the spaces occupied by the summit-plates of the spicules. Within each of these areas the cross formed by the four transverse rays can be distinguished (Pl. II, fig. 1 *b*), and occasionally at the centre of this a small circular aperture indicates the entering ray of the spicules. In other conditions of preservation the rhomboidal areas are not shown, and the surface of the specimen exhibits only the vertical and concentric lines formed by the transverse spicular rays (Pl. II, fig. 1 *a*).

Mr. Salter[1] has figured this species with a short stem and diverging rootlets, and he has stated that specimens possessing these appendages occur at Llangollen. I have not met with any example in the museums at Cambridge or at Jermyn Street showing the least indications of these structures, and it is evident from their absence in the remarkable perfect specimens from the Isle of Gothland, which were kindly lent to me by Prof. G. Lindström, of Stockholm, that Mr. Salter's figures are purely diagrammatic.

The type of this species, and of the genus as well, is preserved in the museum of the Geological Society, Burlington House. It shows the casts of several individuals on a slab of hard, bluish, calcareous shale. In common with other members of this family, considerable numbers of these Sponges appear to have generally lived in close association with each other. The types of *Ischadites antiquus*, Salter, and *I. tessellatus*, Salter, both in the Museum of the Geological Survey, Jermyn Street, do not appear to me to be separable from *I. Kœnigii*.

Distribution.—Ordovician: Lower Llandeilo; Garn, Arenig Mountain, Wales. Caradoc; also in Galena Beds; at Seale's Mound, Illinois, and in Iowa. Orthoceras Limestone; Reval, Esthonia. Silurian: Woolhope Beds; Malvern; near Buildwas, Shropshire. Wenlock shales and limestones; Dudley, Usk, Malvern, Walsall, Balcletchie, Penkill, Ayrshire. Lower and Upper Ludlow; Ledbury, and near Ludlow; Pentland Hills, Scotland; Visby, Westergarn, near Klintehamn, Djupvik, Isle of Gothland; Niagara Group; Waldron, Indiana; Yellow Springs, Ohio; Lower Helderberg Group; Gaspé, Province Quebec.

[1] 'Cat. Cambrian and Silur. Foss. Cambridge,' p. 100.

SILURIAN SPONGES.

Sub-order.—Monactinellidæ.

Genus.—Atractosella,[1] *Hinde*, gen. nov.

The form of the Sponge is unknown, the genus is proposed to include detached spindle-shaped spicules, with blunted extremities. In some spicules the central portion is thickest, and they gradually and evenly taper to both ends, but more frequently the greatest thickness is nearer one end of the spicule than the other, and thus it tapers abruptly to one extremity and gradually to the other.

8. Atractosella siluriensis, *Hinde*, sp. nov. Plate I, figs. 6, 6 *a*—6 *d*.

The spicules are circular in transverse section; they vary from ·82 mm. to 1·62 mm. in length, and from ·12 to ·25 in thickness; judging from broken fragments, even larger forms are also present. Their surfaces are smooth and even. The spicules retain their siliceous structure, and in some the axial canal is shown. As the spicules are entirely detached from each other, there are no means of determining the nature of the Sponge to which they belong, but provisionally they may be referred to the Monactinellidæ. Spicules of this order are very rare at this horizon, and no others have as yet been met with in this country. The forms figured were discovered by Mr. John Smith, of Kilwinning, in decayed limestones.

Distribution.—Silurian: Wenlock Beds, near Craven Arms, Shropshire.

Sub-order.—Hexactinellidæ.

Family.—Protospongidæ.

Genus.—Plectoderma, *Hinde*.

1883. Catalogue Fossil Sponges Brit. Mus., p. 132.

Generic Characters.—Entire form of Sponge unknown; the wall consists of a thin spicular meshwork composed of cruciform and five-rayed spicules, and possibly

[1] ἄτρακτος, a spindle, dimin.

also of linear spicules, which are grouped together, so that the spicular rays which extend the length of Sponge form, by their apposition and overlapping each other, continuous spicular fascicules, whilst the transverse rays extend singly on either side of the vertical rows, and overlap those from the adjoining rows, so as to produce an irregular framework. Smaller spicules are irregularly interspersed in the intervals between the larger.

This genus is closely related to *Protospongia*, Salter, and *Dictyophyton*, Hall; but the arrangement of its spicular mesh is far less regular than in either of these genera, and there are no definite quadrate areas. From *Protospongia* it is further distinguished by the fascicular grouping of the spicular rays in a vertical direction.

9. Plectoderma scitulum, *Hinde*. Plate III, figs. 1, 1 *a*, 1 *b*.

1883. Plectoderma scitulum, *Hinde*. Cat. Foss. Spong., p. 132, pl. xxxi, figs. 1 1 *a*, 1 *b*.

The fragment of the Sponge-wall which has been preserved is about 60 mm. in width and 45 mm. in height; it probably formed part of a cup- or funnel-shaped sponge. The vertical fascicles are about 7·5 mm. apart from each other; there are from five to ten spicular rays in close juxtaposition in each fascicle, but from their present condition it cannot be determined whether they were laterally cemented together or not. The spicules vary greatly in size; the rays of the slender forms are not more than ·09 mm. in thickness, whilst in some of the larger forms the rays are ·35 mm. in thickness, and 6·5 mm. in length. The rays are straight, curved, or occasionally wavy, they usually taper very gradually from the central node to their extremities. Traces of smaller spicules can be occasionally seen in the interspaces between the larger, and it is probable that they formed part of a continuous spicular membrane extending between the framework formed by the larger spicules.

The type-specimen, the only one hitherto discovered, is preserved on the surface of a soft, micaceous, shaly rock. The spicules are now mostly represented by empty casts, but in some cases fragments of the original siliceous spicules, still retaining their axial canals, are preserved. The wall at first sight appears to consist of rod-like spicules, crossing each other at right angles, but where the spicules are less thickly grouped together the four rays of a spicule springing from a centre can be distinctly seen, and at the common centre there is often a small circular aperture, indicating a fifth ray extending inwards at a right angle to the

other four in the plane of the wall. It is very likely that rod-like spicules may also be intermingled with the cruciform and five-rayed spicules.

The type-specimen is in the collection of the Geological Survey of Scotland, Edinburgh.

Distribution.—Silurian: Upper-Ludlow strata; Wetherlawlinn, Pentland Hills, near Edinburgh.

Genus.[1]—Phormosella, *Hinde*, gen. nov.

Generic Characters.—Spherical or sacciform Sponges, apparently free. The skeleton consists of a delicate wall of spicular tissue, composed of cruciform spicules, so disposed that their rays mark out sub-quadrate areas, which are filled in with smaller spicules so as to form a connected meshwork.

This genus is proposed to include some small Sponges which are preserved as compressed oval markings on the surface of a slab of arenaceous rock. Only the impressions of the spicules in iron-peroxide are shown; their arrangement differs from that in the allied genus *Protospongia*, in that there is only a single series of squares in which the smaller spicules are somewhat irregularly disposed. The larger spicules are not grouped in bundles as in the vertical series of *Plectoderma* and in *Dictyophyton*, but they are disposed singly, so that their rays overlap and form vertical and transverse lines.

10. Phormosella ovata, *Hinde*, sp. nov. Plate III, figs. 2, 2 *a*, 2 *b*.

The Sponges are circular or oval in outline, without trace of a stem or point of attachment. They vary from 12 to 17 mm. in diameter. No summit-aperture is perceptible, since all the specimens appear to have been compressed laterally so that they are now mere films on the rock-surface. The rays of the larger cruciform spicules, which mark the sides of the squares, are from 2 to 3 mm. in length. The spicular axes, though generally longitudinal and transverse with respect to the Sponge, sometimes diverge slightly, so that the vertical and horizontal lines are not always strictly continuous. The smaller spicules of the skeleton are very indistinctly seen; they do not exhibit any regular arrangement. In some specimens there are minute punctate elevations and depressions, probably indicating a fifth ray in some of the spicules.

[1] φορμός, anything plaited, dimin.

The only form with which the present species can be compared is that described by the late Dr. Holl[1] under the name of *Protospongia maculæformis*. Judging from the short description, unaccompanied by a figure, this form, which occurs under similar conditions of preservation, belongs to the genus *Phormosella*. It is about as large again as *P. ovata*. Unfortunately the type specimen has been lost, and no other is known.

Phormosella ovata is of rare occurrence, but judging from the number of individuals associated together on the same slab as represented by fig. 2, it appears to have been of a gregarious habit. The type specimen is in the Museum of the Geological Survey, Jermyn Street.

Distribution.—Silurian: Aymestry Rock, Mocktree, Shropshire.

Genus.—DICTYOPHYTON, *Hall.*

1863. Sixteenth Annual Report State Cabinet, New York, p. 87.

Syn.—Hydnoceras, *Conrad;* Tetragonis, *M'Coy, Salter, F. Roemer* (in part).

Generic Characters.—Cylindrical, prismatic, or cup- or vase-shaped Sponges, probably free, since neither stem nor anchoring appendages have been discovered.

The walls consist of a connected spicular framework disposed so as to form rectangular, quadrate, or oblong areas, which may be subequal or of larger and subordinate squares. The character of the spicules of the framework is not fully known, they appear to be arranged in bundles, but whether these bundles are composed of cruciform, or merely rod-like, spicules has not yet been determined. A thin membrane appears to have extended over the area between the framework. The mode of union of the spicules is not definitely known.

The type of the genus was regarded by Conrad[2] as representing a sub-genus of *Orthoceras*, which he named *Hydnoceras tuberosum*. Subsequently Prof. James Hall believed it to be the frond of a marine alga, and with Conrad's consent changed the generic name to *Dictyophyton*. In 1879 the late Prof. Schimper[3] expressed doubts as to its plant nature, and stated that its structure much nearer resembled the skeleton of siliceous Sponges. Later, Ferd. Roemer[4] pointed out the similarity of its structure to that of *Tetragonis Danbyi*, M'Coy. After this, Mr. R. P. Whitfield[5] compared this genus, with other allied forms, to Sponges like the

[1] 'Geol. Mag.,' vol. ix (1872), p. 350.
[2] 'Journ. Nat. Sci. Phil.,' vol. viii, p. 267.
[3] 'Zittel and Schimper's 'Handb. der Pal.,' Bd. ii, Lief. 1, p. 69.
[4] 'Lethæa pal.,' Th. i, p. 127.
[5] 'Amer. Journ. of Science,' vol. xxii, p. 53.

recent *Euplectella*, and its Sponge character has been generally accepted by later authors, including Prof. Hall,[1] who has placed it with several other genera in a separate family of fossil reticulate Sponges; but the structural features of these genera are not stated with sufficient clearness for an opinion to be formed as to their value, and the characters assigned to the family are equally indefinite.

As a general rule, the examples of this genus only occur in the form of casts, in which the structure of the Sponge-wall is represented either by depressed or raised longitudinal and transverse lines, forming regular squares in an arenaceous matrix, and a thin film extends over the areas between the lines. Some of the raised lines are stronger than others, and mark out larger squares, within which subordinate squares are indicated by lighter impressed lines. Both the longitudinal and transverse lines are continuous, and the extreme regularity of their course seems to indicate that their component spicules must have been firmly united together. In these casts the wall of the Sponge appears to consist of but a single layer of spicular tissue.

Mr. R. P. Whitfield[2] has stated that the longitudinal and transverse fibres in *Dictyophyton cylindricum* are composed of bundles of cylindrical spicules of various sizes and of great length, but no mention is made of the presence of cruciform spicules. Prof. Hall[3] also states that "the structure of the frond which characterises every member of this family may be described as a reticulation of tubular spicules forming rectangular meshes;" but here again nothing is said of the form of the spicules. This author also refers to three spicular layers in the wall—a middle layer, which is uniformly reticulate, and inner and superficial layers, which show an oblique and sometimes a radiate arrangement of spicules; but these are not shown in any example of *Dictyophyton* which he has figured.

Assuming that the lines shown in the casts of *Dictyophyton* are really composed of fascicles of spicules, this genus is distinguished from *Protospongia*, Salter, by the fact that the quadrate areas of the wall in this latter form consist only of individual spicules. It differs likewise from *Plectoderma*, Hinde, in the regular arrangement of the surface squares and in having the transverse lines of the wall of spicular fascicles, instead of individual forms.

The earliest appearance of *Dictyophyton* is in the Upper-Ludlow strata of this country, it also occurs in the Middle Devonian of the Eifel, Germany, and New York, and attains its greatest development in the Upper Devonian (Chemung Group) of North America, and it is also present in the same formation (Psammites du Condroz) in the Ardennes (Barrois). It makes its last appearance in the Lower Carboniferous of Ohio and Indiana.

[1] 'Thirty-fifth Annual Report New York State Museum' (1884), p. 465.

[2] 'Bulletin No. 1, Amer. Mus. Nat. Hist.,' December, 1881, p. 19.

[3] 'Thirty-fifth Annual Report on the New York State Museum,' p. 465.

11. Dictyophyton Danbyi, *M'Coy*, sp. Plate II, figs. 4, 4 *a*, 4 *b*, 4 *c*.

1852. Tetragonis Danbyi, *M'Coy.* Brit. Pal. Foss., p. 62, pl. i d, figs. 7, 8.
1854. — — *Morris.* Cat. Brit. Foss., p. 90.
1872. — — *Murchison.* Siluria, 4th edit., p. 509.
1873. — — *Salter.* Cat. Cambrian and Sil. Foss. Cambridge, p. 176.
1880. — — *F. Roemer.* Lethæa pal., p. 304.
1881. — — *Whitfield.* Bulletin Amer. Mus. Nat. Hist., No. 1, p. 14.
1883. — — *F. Roemer.* Zeitschr. d. deutsch. geol. Gesellsch., p. 707.
1883. Dictyophyton Danbyi, *Hinde.* Cat. Foss. Sponges, p. 131.

Sponges sub-ovate or sub-conical in form, growing from an obtuse basal point, without stem, root, or point of attachment, the base is flattened or convex, the greatest width in some specimens is just above the base, in others about half the height of the Sponge, from this it gradually tapers to the summit, which appears to have been open. The specimens vary between 23 and 30 mm. in height, and from 14 to 17 mm. in width.

The Sponge-wall appears to have been smooth and even; the larger areas of the rectangular meshwork are marked out by more prominent, vertical, and transverse raised lines, and vary from 1·5 to 3 mm. in length, and these are subdivided by finer lines into smaller squares, the sides of which are about ·75 mm. in length. In some cases the stronger lines forming the larger squares are nearly parallel from the base to the summit, whilst in others they converge to each other towards the base.

No spicular structure whatever has been preserved in any of the specimens yet discovered, which are merely casts in a matrix of micaceous sandstone. No structure can be detected in the interior of the specimens.

Mr. Salter, according to M'Coy's statement, referred this species to *Receptaculites;* by M'Coy himself it was placed in the genus *Tetragonis*, Eichwald, and apparently regarded as belonging to the Echinodermata; and in Morris's Catalogue it is also placed in this group. Ferd. Roemer likewise includes this species under *Tetragonis*, and calls attention to the resemblance between the surface characters of another form of this genus and *Dictyophyton.* Subsequently I placed the species in *Dictyophyton*, as its structure, so far as a comparison is possible from merely the casts of the organism, agrees closely with that of *D. tuberosum*, Conrad, the type of the genus. It is now known that the genus *Tetragonis*, Eichwald, is merely a synonym of *Ischadites*, Murch., and its characters markedly differ from those of *Dictyophyton.*

Dictyophyton Danbyi is readily distinguished by its small size and the slighter character of its spicular framework from other species of the genus. The specimens represented on Pl. II, figs. 4, 4 *a*, are the type-forms described by M'Coy, now in the Woodwardian Museum at Cambridge. The other specimen, 4 *b*, represents the concave impressions of two individuals which, with the imperfect casts of five others, are exposed on the surface of a small slab of rock, now in the Museum of the Geological Society, Burlington House.

Distribution.—Silurian: Upper-Ludlow-beds at Brigsteer, Benson, Underbarrow, Kendal, Westmoreland.

12. Hyalostelia gracilis, *Hinde*, sp. nov. Plate I, figs. 5, 5 *a*—5 *e*.

The form of the Sponge unknown, the detached spicules referred to the species are either simple hexactinellids with the normal number of rays, or modified spicules in which one ray or one axis is absent. The vertical axis of the spicules is generally longer than the transverse, and varies in length from ·675 to ·95 mm. The transverse rays are generally imperfect; in some cases they form an oblique angle with the vertical axis of the spicule. The spicular rays, with one exception, are smooth and tapering, and apparently terminate obtusely. They vary from ·05 to ·2 mm. in thickness. The rays in one spicule are furnished with obliquely projecting spines.

Associated with the body-spicules are some fragmentary, elongated, cylindrical rods, about ·12 mm. in thickness, with, in places, minute spines disposed spirally, which may be portions of anchoring spicules. Both these and the body-spicules are siliceous, and their axial canals are usually preserved.

These various forms of spicules were discovered by Mr. J. Smith, of Kilwinning, mingled together in a bed of decayed limestone, and it is probable that they belong to the same species.

Distribution.—Silurian: Wenlock strata, near Craven Arms, Shropshire (J. Smith).

13. Ischadites Lindstrœmi, *Hinde*. Plate II, figs. 2, 2 *a*.

1884. Ischadites Lindstrœmi, *Hinde*. Quart. Journ. Geol. Soc., vol. xl, pl. xxxvi, fig. 2.

— Grindrodi, ? *Salter*, MS. (See Bigsby's Thesaurus Siluricus, p. 4, 1868.)

Hemispherical or ellipsoidal Sponges, with broad, markedly concave bases, and round or somewhat depressed summits. They vary from 50 to 100 mm. in width; on account of the compressed condition of all the specimens their height has not been ascertained.

The rhomboidal spicular plates in the basal and zonal regions of the Sponge vary from 3·5 to 5 mm. in extreme width, whilst near the summit aperture they are not more than 1 mm. wide. The summit aperture is about 3 mm. in width.

This species is distinguished from *Ischadites Koenigii*, Murch., by its larger proportions, the concavity of the base, and the somewhat larger dimensions of the spicular summit-plates. Only casts of this species are known, and these generally exhibit the concave basal portion; but in specimens from the Grindrod Collection, now in the Natural History Museum at Oxford, the upper surface is exposed to view; and in one instance the casts of the spicular plates are preserved, as shown in fig. 2 *a*.

As in the case of *I. Koenigii*, this species likewise appears to have been gregarious, several individuals occurring on the same slab of rock in close proximity to each other.

In Bigsby's 'Thesaurus Siluricus' *Ischadites Grindrodi*, Salter, MS. is included; this name may possibly refer to the present species, but as neither specific description nor figure of it has ever been published, and there are no means of definitely ascertaining the type form, I have judged it best to adopt a distinct name for the present species in order to avoid ambiguity.

Distribution.—Silurian: Wenlock shale, Malvern. Lower Ludlow; Ledbury. Also in the lowest beds of the Silurian at Petesvik and Hablingbo, Isle of Gothland (Lindström).

Genus.—AMPHISPONGIA, *Salter.*

1861. Memoirs Geological Survey Great Britain, Sheet 32 Scotland, p. 135.

Sponges elongated-oval or elliptical in outline, greatly compressed, free, with rounded bases and summits. No traces of a canal-system. The basal portion consists of robust, relatively large, conical spicules, disposed side by side nearly in contact with each other, so that their pointed ends converge to the central axis of the Sponge, whilst their distal rounded summits form the basal surface. The upper portion of the Sponge consists of slender four- and five-rayed spicules with the rays at right angles to each other. These apparently are modified hexactinellid spicules. The spicules are regularly arranged so that their rays lap over and

dovetail into each other and form a close, even spicular tissue. There are traces of slender filiform spicules forming an outer layer to the upper portion of the Sponge. The spicules are not organically united together.

Mr. Salter regarded *Amphispongia* as a Calcisponge, and Dr. Bowerbank held the same opinion. The spicules of the upper portion of the Sponge were described as three-rayed forms similar to those of recent Calcisponges, whilst those of the basal portion were stated to be bundles of simple spicules. The fact that in all cases the spicular structures are now only represented by moulds or casts, which are mostly empty or occasionally refilled with a loose powdery iron-rust, not only gave rise to the mistake as to the form of the spicules but also confirmed the idea that they must have been originally of carbonate of lime, since at the time when Salter described this genus it was generally supposed that siliceous fossils would not be liable to dissolution the same as structures of calcite. It is clear, however, from the form of the spicules and from the presence of five rays in many of them, that they are related to siliceous hexactinellids, and the existence of undoubted siliceous Sponges, such as *Plectoderma* for example, in these same beds, and for the most part in a similar condition of preservation, shows the untenability of the theory that since the spicules are dissolved they must necessarily have been originally calcareous.

But whilst the character of the spicules of the upper portion of the Sponge shows its relationship to the Hexactinellidæ, the mode in which they are interwoven together is altogether distinct from that of any other member of this group, and the presence and the arrangement of the peculiar conical spicules in the basal portion of the Sponge is similarly abnormal, so that *Amphispongia* stands quite apart from other hexactinellids.

The genus is only represented by a single species, which appears to be limited to a definite stratum of decayed limestone of Upper-Ludlow age in the Pentland Hills.

14. Amphispongia oblonga, *Salter*. Plate III, figs. 3, 3 *a*—3 *f*.

1861. Amphispongia oblonga, *Salter*. Mem. Geol. Survey Great Britain, Sheet 32 Scotland, p. 135, t. 2, f. 3.
1872. — — *Murchison*. Siluria, 4th edit., p. 509.
1877. — — *Zittel*. Studien, Abtheil. 1, p. 45, Note.
1879. — — *Nicholson*. Manual of Palæontology, 2nd ed., vol. i, p. 135, figs. 33 *c*, *d*.
1880. — — *F. Roemer*. Lethæa pal., p. 317.
1883. — — *Hinde*. Cat. Foss. Sponges, p. 154, pl. xxxiii, figs. 12, 12 *a*—12 *d*.

The general outline of these Sponges is that of an elongated ellipse; the sides are occasionally straight, but usually slightly curved. The basal portion is in most cases narrower than the summit, it is evenly rounded, and there are no traces of stem or of fibres by which it might have been attached. The basal and lateral margins are clearly defined; the summit portion is less frequently exposed, but it appears to have been evenly rounded. There is considerable variation in the size of different specimens; a small example measures 17 mm. in length by 8 mm. in width, whilst a large form is 60 mm. in height by 23 mm. in width. In the present compressed condition the thickness of the Sponge is inconsiderable, about 1 mm. in the upper portion and 2·5 mm. at the base.

It is uncertain whether a central cloacal cavity existed, but it is possible that the upper portion of the Sponge may have originally been a hollow sac with thin walls, which are now compressed together. In one specimen I have seen indications of a narrow cavity in the basal portion.

The conical spicules extended from one-fourth to one-half of the entire length of the Sponge. Judging from casts, their surfaces were smooth and even, and they tapered evenly from the rounded head to the pointed extremity. They varied from 2 to 3 mm. in length, and from ·5 to 1 mm. in thickness. At the extreme base of the Sponge these conical spicules pointed directly upwards, whilst on the sides they are disposed obliquely to its axis, their points being directed downwards and inwards. The four- and five-rayed spicules forming the upper portion of the Sponge are very much smaller than the conical basal spicules, on which they directly rest. They are so closely arranged that, as a rule, only the casts of one spicular axis and the small aperture of a third ray can be seen on the exposed surface of the Sponge, and their real forms can only be ascertained from the casts of the detached individuals, which are fairly abundant in the matrix associated with the conical spicules. The rays of the smaller spicules are straight, they very gradually taper from the central node, and they vary from ·5 to 1 mm. in length, and about ·12 mm. in thickness. The slender filiform spicules are seldom preserved, they appear to have been arranged somewhat obliquely to the length of the Sponge, and to have been restricted to its upper portion.

All the examples of this species hitherto found are preserved as casts in a soft brown, micaceous, somewhat shaly rock. They are extended on the bedding-plane of the rock, sometimes in a uniform direction with respect to each other, and in such numbers as nearly entirely to cover the surface (Pl. III, fig. 3).

The type of the species is now in the Museum of the Geological Survey, Jermyn Street, but much better preserved specimens have been discovered since the form was first described, and these are now in the British Museum, and in the Museum of Science and Art, Edinburgh.

Distribution.—Silurian: Upper-Ludlow strata; Wetherlawlinn, Pentland Hills, near Edinburgh.

Sub-Order.—Octactinellidæ.

Genus.—Astræospongia, *F. Roemer.*

1860. Silur. Fauna Tennessee, p. 14.

Syn.—Blumenbachium, *F. Roemer* (non *Koenig*) ; Astræospongium, *F. Roemer ;* Octacium, *Schlüter.*

Generic Characters.—Sponges discoid or shallow cup-shaped in form, and without stem or any surface of attachment. No special canal-system indicated in the skeleton, which is composed of spicules having six rays extending in a plane from a common centre, at equal angles from each other, and with a vertical axis. One or both rays of the vertical axis may be reduced or not be developed. The spicules are irregularly arranged, with their horizontal rays generally parallel to the surface of the Sponge ; they are quite free from each other.

Though the spicular elements of the skeleton in this genus do not appear to have been organically attached together, entire Sponges are of not infrequent occurrence. In these the spicules are now cemented together by the matrix, and they are best preserved on the weathered surface of the Sponge. The rays in some of the larger spicules show, when weathered, longitudinal open furrows, indicating the presence of canals. Many of the examples of this genus are now composed of carbonate of lime, and even the detached spicules met with in the rocks consist of the same mineral. In some, however, the exterior is of carbonate of lime, whilst the interior is a mass of chalcedonic silica, in which the spicular structure has been obliterated. The frequent occurrence of these calcitic specimens has given rise to the belief that the Sponges originally consisted of this mineral, and Ferd. Roemer[1] supports this view by the statement that other Sponges, as *Astylospongia* for example, occurring, with *Astræospongia* in the same beds in Tennessee, are completely silicified. But it does not thereby follow that this latter genus is a Calcisponge, since we know that many of the Silurian examples of *Aulocopium*, a generally recognised siliceous Sponge, are partly of calcite and partly of chalcedonic silica, like some of the Tennessee specimens of *Astræospongia*. The form and general character of the spicules of this genus, moreover, do not indicate any affinity with recognised Calcisponges, and I therefore regard the calcareous specimens as replacements after silica.

The spicules of *Astræospongia* have been described by F. Roemer as consisting only of six horizontal rays, and Schlüter,[2] maintaining the same opinion, has con-

[1] 'Lethæa palæozoica' (1880), p. 314.

[2] 'Sitzungsb. d. niederrhein. Gesellsch. in Bonn,' 1885, p. 151.

stituted a new genus, *Octacium*, for spicules in which a vertical axis is present in addition to the horizontal rays. But Zittel[1] has pointed out that the spicules, even in the typical species, show indications of a vertical axis, though one or both of its rays may be reduced to a mere rudimentary process, and therefore the fully developed spicules in *Astræospongia* may be regarded as possessing eight rays.

The spicules of this genus are so distinctly marked off from those of any other group of Sponges that in my opinion they characterise a separate sub-order. The constancy and the regular disposition of the six horizontal rays, and the additional rays of the vertical axis, clearly show that the genus cannot be ranked with the Hexactinellidæ. The same features likewise distinguish it from any of the genera included in the Heteractinellidæ, though some of the spicules of *Tholiasterella*, consisting of six horizontal rays and a vertical ray, bear a certain resemblance to those of *Astræospongia* (Pl. VII, figs. 1 *c*, 1 *d*). But in *Tholiasterella* the horizontal rays are very inconstant, varying from five to nine in number, and further, their mode of union with each other also indicates the absence of any real affinity between these groups.

The genus *Astræospongia* makes its first appearance in the Silurian (Niagara group or Wenlock) and passes up into the Devonian. It occurs in North America; Isle of Gothland, Sweden; England; Eifel, Germany; and in Belgium.

15. Astræospongia patina, *F. Roemer*. Plate I, figs. 7, 7 *a*—7 *d*.

1861.	Astræospongia patina,	*F. Roemer.*		Fossile Fauna d. Silur. Geschiebe von Sadewitz, p. 14, pl. iii, figs, 5 *a*—5 *d*.
1880.	—	—	—	Lethæa pal., p. 315.
1883.	—	—	*Hinde.*	Cat. Foss. Sponges, p. 149, pl. xxxi, fig. 5.

The Sponges are discoid, with rounded, convex bases, and shallow, concave upper surfaces. The type specimen is stated to be 41 mm. in width and 20 mm. in height.

The skeletal-spicules exhibit well-marked, flattened, central discs; the rays taper very slightly as a rule, and terminate obtusely. In many, only the six horizontal rays are developed, in others one ray of the vertical axis is present as a small projection from the centre of the disc, whilst more rarely some possess both rays of the vertical axis. In one abnormal spicule only three horizontal rays are

[1] 'Handbuch der Pal.,' Bd. i, 1879, p. 185.

present. The spicules vary from ·36 to 1·5 mm. in diameter, and the rays are from ·033 to ·137 mm. in thickness.

Only detached spicules of this species have, as yet, been recognised in this country, and these were discovered, sparsely distributed in decayed shaly limestones, by Mr. John Smith, of Kilwinning. The spicules are all imperfect; they correspond very closely with those of the type form from the Glacial Drift of Sadewitz, Lower Silesia, and with the detached spicules which I obtained from the Isle of Gothland. They are now of calcite.

Distribution.—Silurian: Wenlock shale, Wren's Nest, Dudley; Dormington; Lincoln Hill; Benthall Edge; Malvern, at the west end of the Tunnel.

Also in the Isle of Gothland and in the Drift of Sadewitz, Northern Germany.

DEVONIAN SPONGES.

Family.—RECEPTACULITIDÆ.

Genus.—SPHÆROSPONGIA, *Pengelly.*

1861. Geologist, vol. iv, p. 340.

Syn.—Sphæronites, *Phillips*, *F. Roemer*, *Bowerbank*, *Austin;* Echinosphærites, *Murchison*, *Keyserling*, *Verneuil;* Pasceolus, *Kayser;* Polygonosphærites, *F. Roemer*, *Zittel.*

Generic Characters.—Pyriform, cup- or funnel-shaped Sponges, growing from an obtusely-pointed, frequently incurved, base; without stem or attachment of any kind. The summit in some specimens is dome-shaped and appears to have been mostly inclosed, whilst in other examples it is widely open.

The outer surface of the Sponge-wall consists of smooth, hexagonal plates, regularly arranged in quincunx. Beneath the plates are the four transverse rays of the spicules, which form vertical and concentric ridges on the inner side of the Sponge-wall. An entering ray, like that in *Ischadites*, is either absent or only represented by a short knob-like process.

This genus was first referred by Mr. W. J. Broderip to the Tunicata; then it was placed by Prof. J. Phillips, as a Cystidean, in the genus *Sphæronites*, Hisinger; and subsequently Mr. Pengelly, who first discovered the characters of the interior, described it as a Sponge, and constituted for it the genus *Sphærospongia.* Still later, the form was referred by Kayser to *Pasceolus*, Billings; and Ferd. Roemer, whilst recognising its relationship to *Receptaculites*, Defrance,

denied its claim to be regarded as a Sponge, and, therefore, proposed for it the generic name of *Polygonosphærites*.

This genus is distinguished from other members of the family by its form, by the regular hexagonal figure of the spicular plates, and by the absence of entering spicular rays.

The genus appears to be limited to Devonian strata; it has been met with in Devonshire, in Germany, and in Russia.

16. SPHÆROSPONGIA TESSELLATA, *Phillips*, sp. Plate IV, figs. 2, 2 *a*—2 *d*.

1832 TUNICATE FOSSIL, *Broderip*. Trans. Geol. Soc., ser. 2, vol. iii, p. 164, pl. xx, figs. 1, 2.
1841. SPHÆRONITES TESSELLATUS, *Phill.* Pal. Foss. Devon, &c., p. 135, pl. lix, fig. 49.
1844. — — *F. Roemer*. Rhein. Uebergangsgeb., p. 64.
1845. ECHINOSPHÆRITES — *Murch.*, *Keyserl.*, *Vern.* Geology of Russia, p. 381, pl. xxvii, fig. 7.
1845. SPHÆRONITES — *Bowerbank*. Ann. and Mag. Nat. Hist., vol. xv, p. 299.
1845. — — *Austin*. Idem., p. 406.
1854. ECHINOSPHÆRITES — *Morris*. Cat. Brit. Foss., p. 79.
1850–56. PROBOSCIS OF CRINOID, *G. and F. Sandberger*. Verstein. des Rhein. Schicht.-Syst., pp. 384, 385.
1861. SPHÆROSPONGIA TESSELLATA, *Pengelly*. Geologist, vol. iv, p. 340, pl. v.
1875. PASCEOLUS TESSELLATUS ET RATHI, *Kayser*. Zeitschr. d. deutsch. geologisch. Gesellsch, p. 780, pl. xx.
1880. POLYGONOSPHÆRITES TESSELLATUS, *F. Roemer*. Leth. geogn., Th. 1, p. 297, fig. 54.
1880. — — *Zittel*. Handb. der pal., vol. i, p. 728.
1883. DICTYOPHYTON GEROLSTEINENSE, *F. Roemer*. Zeitschr. d. deutsch. geologisch. Gesellsch., p. 706, figs. *a*, *b*.
1884. SPHÆROSPONGIA TESSELLATA, *Hinde*. Quart. Journ. Geol. Soc., vol. xl, p. 840, pl. xxxvii, figs. 1, 1 *a*—1 *c*.

The examples of this species show many gradations of form between open cup-shaped and pyriform, and they are equally as variable in size. The type specimen, though imperfect, is 85 mm. in height and 115 mm. in width near the summit. The average height of a number of examples in the British Museum is 60 mm., and they are nearly of the same width.

The hexagonal spicular plates, forming the outer surface of the Sponge, are nearly flat, with a small central rounded elevation, which, however, is only seen in the best-preserved specimens; the plates also exhibit delicate concentric lines, resembling lines of growth, and occasionally their margins are slightly elevated. The plates near the base of the Sponge are the smallest, whilst those of the middle and upper portions are about equal in size. They vary from 2·5 mm. to 7·5 mm. in width. Though apparently the plates are in close contact with each other, yet many specimens show narrow linear interspaces between their margins.

The transverse spicular rays, forming vertical and concentric ridges within the Sponge, gradually taper from their central node and terminate obtusely; those extending horizontally are not infrequently curved and less regular than those of the vertical ridges. The rays are slightly unequal in length, and frequently overlap, so that when fused together by fossilization their individual forms are not readily distinguishable.

As a general rule, the specimens showing the exterior surface are infilled with a solid calcareous matrix, whilst in the hollow specimens the surface-plates are concealed by the rock. Fragments, however, occur in which both the outer and inner structures of the wall can be recognised. In all the specimens discovered, the structures are replaced by carbonate of lime.

In a lately published paper,[1] Prof. Schlüter proposes to include as distinct species of *Sphærospongia*, *Scyphia cornucopiæ*, Goldfuss, *Pasceolus Rathi*, Kayser, and *Dictyophyton gerolsteinense*, F. Roemer, as well as three new species, *S. sculpta*, *S. vichtensis*, and *S. megarhaphis*. The characters of these species for the most part depend upon slight differences in the size of the specimens and of the individual spicular plates of their surfaces, and the specimens are very fragmentary. Judging from the great variability in these features shown in the suite of specimens of *S. tessellata* from Newton-Bushell, I do not think these differences have any specific value, at least as regards the forms described by Goldfuss, Kayser, and F. Roemer, whilst I hesitate to express an opinion as to the new species proposed.

The type of the species, represented on Pl. IV, fig. 2, is now in the Museum of the Geological Survey, Jermyn Street.

Distribution.—Middle Devonian: Newton-Bushell, Devonshire. Also at Vilmar, Nassau; Eifel, Germany; River Jolva, near Bogoslofsk, Ural, Russia.

[1] 'Zeitschr. d. deutschen geolog. Gesellschaft,' 1887, p. 1.

Genus.—Receptaculites, *Defrance.*

1827. Dictionnaire des Sciences Naturelles, tome 45, Atlas, pl. 68.

Syn.—Coscinopora (in part), *Goldfuss, D. Dale Owen.*

Generic Characters.—Cup- or platter-shaped Sponges, growing from a small inverted conical nucleus, and frequently reaching considerable dimensions. Wall thick, the outer or under surface consisting of rhomboidal spicular plates similar to those in *Ischadites*, and, as in this genus, disposed in decussating lines. The four transverse or horizontal spicular rays form radial and concentric lines beneath the surface-plates. The vertical or entering ray of the spicules is sub-cylindrical, frequently constricted near its junction with the transverse rays; at its inner end it expands, to form a small horizontal plate, which is traversed by horizontal canals. By the junction of the inner plates with each other a distinct inner or upper layer of the Sponge-wall is formed, and in one species at least this layer is perforated by cylindrical canals, thus giving communication to the interior space of the Sponge-wall.

This genus is distinguished from all others included in the family by the presence of an inner layer formed by the development of small plates at the extremity of the entering ray of the spicules.

Owing in part to the peculiar aspect of examples of this genus under different conditions of preservation, various views have been held as to its character and affinities. By Defrance and Eichwald the hollow casts of the vertical spicular rays were believed to be polyp-cells, and the genus was placed with Corals. Salter at first regarded it as a Foraminifer allied to the family of the Orbitolitidæ; Billings placed it with Sponges on account of a supposed resemblance to the gemmules of *Spongilla;* by Dames it was placed a second time with the Foraminifera as the type of a family near the Orbitolitidæ; and still later Gümbel retained it in the same class, but included it in the family of the Dactyloporidæ.

The genus makes its first appearance in the Ordovician of North America, Russia, and the Arctic regions; it is present in the Silurian proper at Malvern; Australia, and doubtfully in Canada; in the Devonian of Devonshire, Belgium, the Eifel, and elsewhere in Germany as well as in Canada; and a single somewhat doubtful species is recorded from the Carboniferous Limestone of Silesia.

17. Receptaculites Neptuni, *Defrance*. Plate II, fig. 3, and Plate IV, fig. 1.

1827. Receptaculites Neptuni, *Defrance*. Dict. des Sciences Nat., vol. xlv, p. 5, Atlas, pl. lxviii, figs. 1 *a*, 1 *b*, 1 *c*, 1 *d*.
1826–33. Coscinopora placenta et sulcata, *Goldfuss*. Petref. Germ., Th. 1, p. 31, pl. xix, figs. 18, 19.
1842. Receptaculites Neptuni, *Archiac and Verneuil*. Trans. Geol. Soc., ser. ii, pt. 2, p. 407.
1844. — — *F. Roemer*. Rhein. Uebergangsgeb., p. 59.
1852. — — *Quenstedt*. Handb. d. Petref., p. 670, pl. lx, fig. 18.
1868. — — *Dames*. Zeitsch. d. deutsch. geol. Gesellsch., Bd. xx, p. 483, pl. x, fig. 1.
1875. — — *Gümbel*. Beiträge Abhandl. d. k. bay. Akad. der Wiss., Cl. ii, Bd. xii, Ab. 1, p. 169, pl. A.
1878. — — *Quenstedt*. Petref. Deutschl., Bd. v, p. 596, pl. 142, fig. 20.
1878. — scyphioides, *Quenstedt*. Idem., p. 586, p. 142, figs. 15, 16.
1879. — Neptuni, *Nicholson*. Man. Pal., vol. i, p. 127, fig. 29.
1876–80. — — *Zittel*. Handb. d. Pal., p. 84, fig. 20.
1880. — — *F. Roemer*. Lethæa pal., vol. i, p. 290, Atlas, pl. xxxv, figs. 7 *a*, *b*, *c*.
1882. — — *T. R. Jones*. Cat. Foss. Foram. Brit. Mus., p. 4.
1884. — — *Hinde*. Quart. Journ. Geol. Soc., vol. xl, p. 841.
1885. — — *Vosmaer*. Porifera. Bronn's Klassen u. Ordnungen d. Thier-Reichs, Bd. ii, p. 275.

Sponges varying in form from flattened discs with a circular outline, to open cups, and ranging from 65 to 180 mm. in diameter. The walls, as a rule, gradually increase in thickness, from the conical nucleus, where they are about 3 mm. in thickness, towards the margin of the disc or cup, where they attain a thickness of 10 to 15 mm., and in one exceptional example 20 mm.

The rhomboidal spicular plates of the outer or under surface of the Sponge-wall are usually flat, though in some specimens they become concave through pressure; their edges are thin and usually crenulated beneath. They vary from 4 to 5·5 mm. in width. They are disposed so that a linear interspace exists between adjoining plates, which is shown by the curved decussating ridges in the casts of the outer surface. The transverse or horizontal spicular rays are conical, from 1 mm. to 1·5 in thickness; they usually extend beyond the respective head-

plates, and overlap the rays of adjoining spicules. The ray pointing to the outer margin of the Sponge not infrequently projects over the spicular plate in advance of it. The entering or vertical ray of the spicule is usually contracted immediately beneath its junction with the transverse rays, it then expands and is nearly evenly cylindrical to its junction with the plate of the inner wall. The characters of the plates forming the inner or upper wall in this species have not clearly been made out. They appear to be sub-quadrate in form, and in close contact with each other. It is doubtful whether there were perforations at the angles of the plates, as is clearly the case in *R. occidentalis*, Salter, and in a specimen from the Devonian of Canada, which, in all other respects, resembles the European forms of this species.

The only undoubted example of this species from British strata is a fragmentary individual discovered by the late A. Champernowne, Esq., F.G.S., showing an impression in hardened mudstone of a portion of the inner surface of the wall and transverse sections of the vertical spicular rays (Pl. IV, fig. 1). Fragmentary specimens likewise occur in Wenlock strata at Malvern, which may provisionally be referred to this species, though the characters preserved are insufficient for satisfactory determination. They consist of impressions of the under or outer surface of the wall of flattened specimens of at least 120 mm. in diameter, showing the lozenge-shaped depressions formed by the casts of the spicular plates and traces of the transverse rays beneath them (Pl. II, fig. 3). In none of the specimens is the structure clearly shown, and the principal grounds for referring them to *R. Neptuni* are the correspondence in the form and dimensions and in the crenulated margins of these outer plates to those of typical forms of this species as figured by Gümbel.[1]

Distribution.—Silurian: Wenlock strata, Malvern. Middle Devonian: Mudstone Bay, Devonshire. Also in Devonian strata at Chimay, Couvin, and other localities in Belgium, Ober-Kunzendorf, Silesia; Eifel, Germany; near Widder, Ontario, Canada.

Sub-Order.—Octactinellidæ.

18. Astræospongia Devoniensis, *Hinde*, sp. nov. Plate IV, figs. 8 *a*—8 *c*.

The form of the Sponge unknown; the species is based on detached spicules in which both the rays of the vertical axis are developed, as well as the six horizontal rays. The rays are robust, conical, circular, or slightly compressed in

[1] 'Beiträge Abhandl. d. k. bay. Akad. der Wiss.,' Cl. ii, Bd. xii, pl. A, figs. 3 *a*, 4 *a*.

transverse section, tapering evenly but somewhat abruptly, from the central disc to an obtuse termination. The rays forming the vertical axis, when complete, appear to be as long as the horizontal rays. There is considerable variation in the dimensions of the spicules; the individual rays, measured from the centre of the disc, vary from 1·2 mm. to 3·2 mm. in length and from ·3 to ·6 mm. in thickness at their bases.

The spicules of this species are characterised by the tapering conical form of the rays, and by the development of the rays of the vertical axis. In this latter feature they agree with spicules described by Prof. Schlüter from Devonian Rocks of the Eifel, under the name of *Octacium rhenanum*;[1] but, judging from the figures and measurements given by Prof. Schlüter, the rays in our species, besides being larger, taper more abruptly. In *Astræospongia meniscoides*,[2] Dewalque, also from the Eifel, the spicules are larger than those of the present species, the rays are fusiform rather than conical, and no mention is made of the presence of vertical rays. In *A. Hamiltonensis*, Meek and Worthen,[3] from the Devonian of North America, the spicules are smaller, and do not appear to possess vertical rays.

The forms described and figured were discovered by Mr. J. Smith, of Kilwinning, in decayed limestones. They are now of crystalline calcite, their surfaces are much eroded, and in some instances partially obscured by matrix.

Distribution.—Middle Devonian: Newton Abbott, Devonshire.

CARBONIFEROUS SPONGES.

Sub-Order.—MONACTINELLIDÆ.

Genus.—RENIERA, *O. Schmidt.*

1870. Die Spongien des adriatischen Meeres, p. 72.

Syn.—Rayneria, *Nardo;* Pellina, *O. Schmidt;* Prianos, *Gray.*

Sponges of variable form. The skeleton consists of acerate and cylindrical spicules, which are disposed so as to form a polygonal meshwork; the spicules held together at their ends by spongin.

The connected skeletons of Sponges of this genus are unknown in the fossil

[1] 'Sitzungsb. der niederrhein. Gesellsch. Bonn,' p. 151; 'Zeitschrift d. deutschen geolog. Gesellschaft,' 1887, p. 23, Taf. ii, figs. 7—9.

[2] 'Bull. de l'Acad. Roy. de Belgique,' vol. xxxiv, 1872, p. 24, pl. xxvi.

[3] 'Geol. Surv. Illinois,' vol. iii, p. 419, pl. x, fig. 6.

state, and owing to the fragile manner in which the spicules are held together in the existing species, their preservation as fossils in their normal positions can hardly be expected. Detached spicules closely resembling in form those of existing examples of the genus, but for the most part of larger proportions, are, however, of not infrequent occurrence in Carboniferous and newer strata, and they may provisionally be ranged in this genus.

I have followed Vosmaer in regarding O. Schmidt as the author of the genus, since he not only modified Nardo's original name, but was the first to define the characters of the Sponges assigned to the genus.

19. Reniera Carteri, *Hinde*. Plate IV, figs. 5, 5 *a*—5 *f*.

1879. Spicule of a Renierid Sponge, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. iii, p. 144, pl. xxi, fig. 11.
1883. Reniera ? Carteri, *Hinde*. Cat. Foss. Sponges, p. 19, pl. i, fig. 8.

The detached spicules on which this species is based are smooth, cylindrical, gently arcuate, or with a nearly straight central portion and somewhat abruptly incurved extremities, which in all cases are obtusely rounded. They range from ·8 to 2·5 mm. in length and from ·11 to ·22 mm. in thickness. There are numerous gradations between the extreme forms, which indicate that they probably all belong to a single species.

The spicules are now composed nearly entirely of chalcedonic silica; in a few instances the silica is crystalline. They are now usually solid throughout, in only a single example of those which have come under my notice has the axial canal been preserved. They are fairly abundant and well preserved.

Distribution.—Lower Carboniferous: Upper Limestone series at Glencart, Dalry, Ayrshire.

20. Reniera scitula, *Hinde*, sp. nov. Plate IV, fig. 4.

1880. Reniera ? *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, p. 212, pl. xiv, fig. 14.

The spicules included in this species are cylindrical, smooth, gently arcuate, and with evenly rounded extremities. They vary from ·5 mm. to ·9 mm. in length, and from ·09 mm. to ·15 mm. in thickness. They are now partly of chalcedonic and

partly of crystalline silica. Traces of the axial canal are present in some examples.

These spicules are distinctly smaller and more evenly arcuate than those of *R. Carteri*, from the Carboniferous of Ayrshire. They were obtained by Mr. J. Wright from the decayed chert-bed at Ben Bulben, and described by Mr. H. J. Carter, F.R.S., as "sausage-shaped spicules like those of some of the Reniera of the present day.

Distribution.—Upper beds of Carboniferous Limestone, Ben Bulben, Sligo, Ireland.

21. Reniera clavata, *Hinde*, sp. nov. Plate IX, figs. 5, 5 *a*, 5 *b*.

The spicules of this species are cylindrical, gently arcuate, with slightly inflated extremities, their surfaces smooth and even. They vary from ·36 mm. to ·53 mm. in length, and from ·06 to ·09 mm. in thickness. They are smaller than the preceding species, and characterised by their slightly tumid extremities.

These spicules are the most abundant and widely distributed forms in the Carboniferous Sponge-beds, which in places are filled with them.

Distribution.—Yoredale series: Richmond, Arkendale, Harrogate, Yorkshire; Halkin, Henblas, near Holywell, Gt. Orme's Head, North Wales. Carboniferous Limestone: Clitheroe, Lancashire. Middle Limestone or Calp series: near Dublin.

22. Reniera virga, *Hinde*, sp. nov. Plate IX, figs. 6, 6 *a*, 6 *b*.

This name is proposed for elongated cylindrical spicules, smooth, evenly rounded at both ends, and gently arcuate. In some specimens one end of the spicule is slightly smaller than the other. They vary from ·5 to ·65 mm. in length, and from ·05 to ·06 mm. in thickness. They are distinguished from *R. clavata* by the absence of any inflation at their ends, and they are much more slender forms than *R. scitula.*

Distribution.—Carboniferous Limestone: Clitheroe, Lancashire. Yoredale series: Richmond, Yorkshire; Trelogan, Flintshire. Upper Limestones: Ben Bulben, Sligo.

23. Reniera gracilis, *Hinde*. Plate IX, figs. 7, 7 *a*, *b*.

1885. Reniera gracilis, *Hinde*. Beds of Sponge-Remains in Lower and Upper Greensand, Phil. Trans., p. 436, pl. xli, figs. 1, 1 *b*.

Cylindrical spicules, gently arcuate, smooth, with evenly rounded ends. Average length ·4 mm., thickness ·05 mm. These spicules correspond closely with those described under the above name from the Lower and Upper Greensand of Surrey and Devonshire. They are distinctly shorter than the spicules of *R. virgata*.

Distribution.—Yoredale series: Richmond, Yorkshire.

24. Reniera Zitteli, *Počta*. Plate IX, figs. 8, 8 *a*—8 *c*.

1884. Reniera Zitteli, *Počta*. Sitzungsber. der königl. böhm. Gesellsch. der Wiss., vol. 1884 (1885), p. 8, pl. i, figs. 10—14.
1885. — — *Hinde*. Phil. Trans., p. 437, pl. xli, figs. 4—4 *e*.

Acerate spicules, straight or gently arcuate, smooth, either fusiform and gently tapering to both ends, or nearly even throughout and somewhat abruptly pointed. Length from ·3 to ·5 mm. and from ·03 to ·04 mm. in thickness.

These Carboniferous spicules cannot be distinguished from the forms occurring in the Greensands of Surrey and Devonshire, and in the Cretaceous strata of Bohemia and Westphalia.

Distribution.—Yoredale series: Richmond, Yorkshire; Halkin, Henblas, near Holywell, North Wales. Carboniferous Limestone: Clitheroe. Upper Limestone series: Benachlan, Ben Bulben, Sligo.

25. Reniera bacillum, *Hinde*, sp. nov. Plate IX, fig. 9.

Very slender cylindrical spicules, either gently curved throughout their length, or somewhat abruptly incurved near one or both ends. Their surfaces are smooth, and their extremities evenly rounded. They vary from ·23 mm. to ·5 mm. in length, and ·02 mm. in thickness. These forms are readily distinguishable from those previously described by their slender proportions. They are extremely abundant in some of the cherty Sponge-beds, which are mainly composed of their minute

forms. On weathered surfaces of these beds the spicules have the appearance of a closely felted mass of delicate threads.

Distribution.—Yoredale series: near Harrogate, Yorkshire; Trelogan, Gronant, Flintshire. Upper Limestone series: Benachlan, Fermanagh.

Genus.—Axinella, *O. Schmidt.*

1862. Die Spongien des adriatischen Meeres, p. 60.

Branching fibrous Sponges. Spicules acuate or acerate, straight or curved. In the axial portion of the Sponge the spongin is more developed than near the periphery (Vosmaer).

The genus is based on Sponges now existing in the Mediterranean. Entire fossil forms are unknown, but detached spicules, closely resembling those of existing species, are present in Carboniferous strata and more abundantly in the Greensand and Chalk, and may provisionally be referred to the genus.

26. Axinella vetusta, *Hinde*, sp. nov. Plate IV, fig. 6.

The spicules included in this species are smooth, robust acuates, with evenly rounded summits, gently curved, retaining an equal thickness for about one half their length, then gently tapering to an obtuse point. The specimen figured is 2·3 mm. in length by ·2 mm. in thickness.

This form of spicule is not known earlier than in the Carboniferous Rocks, where it is of rare occurrence.

Distribution.—Carboniferous Limestone: Clitheroe, Lancashire. Upper Limestone series: Glencart, Dalry (J. Smith).

27. Axinella paxillus, *Hinde*, sp. nov. Plate IX, fig. 10.

The spicules in this form are smooth, nearly or entirely straight, of an even thickness for two-thirds of their length, then gradually tapering to an obtuse point. The summit is slightly inflated. An average specimen is 1·45 mm. in length by ·08 mm. in thickness.

This form approaches closely to spicules included in *Axinella stylus*, Hinde

('Phil. Trans.,' 1885, Pl. xli, figs. 8 *a—d*), but it has a distinctly inflated summit; it is a much smaller form than the spicules placed under *A. vetusta.*

Distribution.—Carboniferous Limestone: Clitheroe, Lancashire.

Genus.—HAPLISTION, *Young and Young. Emend. Hinde.*

1877. Annals and Mag. Nat. Hist., ser. 4, vol. xx, p. 428.

Syn.—Rhaphidhistia, *Carter;* Dysidea (in part), *Carter.*

Generic Characters.—Sponges small, ovoid, spheroidal, or discoidal in form, destitute of stem. Skeleton consisting of solid, reticulate, anastomosing fibres, which terminate at the surface in small blunt projections. No special dermal layer preserved. No definite canals beyond the irregular open spaces between the fibres. The fibres are composed of minute, straight, or curved acerate spicules, disposed generally parallel with the direction of the fibre, and interlacing with each other.

The authors of the genus state, in their original description, that "no spicules have been recognised as belonging to the fossil, though the teazed-out tissue lining the canals has a tantalising suggestion of spicules about it. It is not, therefore, absolutely certain that we have to do with a siliceous Sponge; it may be that a horny Sponge like *Dysidea* has become siliceous, as have the Brachiopod shells in the same deposit." Through the kindness of Dr. J. R. S. Hunter, of Carluke, I have been enabled to examine the example of *Haplistion Armstrongi*, described and figured by Messrs. Young as the type of the genus, and the same specimen has been here refigured (Pl. V, fig. 1). It shows very distinctly the minute spicules weathered out on the exterior of the fibres, and there can be no doubt that the type of the genus is a siliceous monactinellid Sponge. The oscula referred to by Messrs. Young are merely the irregular apertures between the reticulating fibres, and the canals are of the same character.

The genus *Rhaphidhistia*, Carter, is based on specimens having all the characters of the present genus, which has the priority of publication; and further, the same author has referred to a new species of *Dysidea* specimens which clearly belong to the typical forms of *Haplistion.*

The examples of this genus are of rare occurrence, and they are at present only known from the Carboniferous series of Ayrshire.

28. Haplistion Armstrongi, *Young and Young*. Plate V, figs. 1, 1 *a*, 1 *b*.

1877. Haplistion Armstrongi, *Young and Young*. Ann. and Mag. Nat. Hist., ser. 4, vol xx, p. 428, pl. xv, figs. 31—37.
1878. Dysidea antiqua, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. i, p. 139, pl. x, figs. 7, 8.
1879. Spongelia antiqua, *F. E. Schulze*. Zeitsch. d. wiss. Zool., Bd. xxxii, p. 126.
1883. Haplistion fractum, *Hinde*. Cat. Foss. Sponges, p. 207, pl. xxxviii, figs. 4, 4 *a*.

Fairly complete specimens are sub-spheroidal or ovoid in form, and apparently free. The type-specimen is 16 mm. in length by 13 mm. in thickness. The reticulating fibres vary from ·14 to ·5 mm. in thickness; they form a network with circular, oval, or irregular polygonal apertures, ranging from ·55 to 1 mm. in width; in the interior of the specimen the meshes are somewhat more open than at the surface. The conical projections in which the fibres terminate are nearly equal in length, and approximately at right angles to the surface of the Sponge. The spicules are thickly disposed on the surface of the fibres, they are straight or slightly curved, apparently terminating bluntly. The longest spicule noticed measures ·32 mm., whilst they vary from ·025 to ·04 mm. in thickness.

Perfect examples of this species are extremely rare; as a rule only small, broken up fragments of the fibres are met with. The outer surface of the fibres has generally a brownish appearance, and when fairly well preserved shows the outlines of the component spicules on the exterior. The interior portion of the fibres is of solid white silica, probably resulting from the fusing together of the original spicules. The spicules on the surface are only shown as the result of weathering, they have an eroded granular aspect; and, owing to the manner in which they overlap and are partially fused together, it is difficult to ascertain their perfect forms. In specimens which have been subjected to a greater degree of weathering the brownish tint of the fibres is changed to a rusty yellow, the outlines of the spicules have disappeared, and the surface of the fibres, and oftentimes the interior as well, consists apparently of minute, irregular granular particles of silica, partially cemented together. In this condition the fibres have somewhat the appearance of those of the existing genus *Dysidea*, and on a specimen thus preserved Mr. Carter based the species *Dysidea antiqua*. I am indebted to Mr. J. Thomson for the opportunity of examining the type form described by Mr. Carter, which corresponds in every respect, except in its condition of preservation, with the type of *Haplistion Armstrongi*. The spicules obtained by Mr. Carter from

washing his specimen, and which were supposed to have been incorporated in its fibres, were most probably derived from the débris infilling the interspaces between the fibres, and did not form part of the fibres themselves. In Dr. Hunter's type specimen of *H. Armstrongi*, the interspaces between the fibres were similarly filled with spicules and other débris; but in none of the specimens which have come under my notice is there any structural connection between these extraneous spicules and the fibres.

At the time of describing *Haplistion fractum* I had not seen an authentic specimen of *H. Armstrongi*, but a comparison with those forwarded to me by Dr. Hunter and Mr. J. Smith leaves no doubt that the fragments I named belong to Messrs. Young's species.

Distribution.—Carboniferous. Upper part of Lower Limestone series: Cunningham Baidland, Law Quarry, Dalry, Ayrshire.

29. Haplistion vermiculatum, *Carter* sp. Plate V, figs. 2, 2 *a*.

1878. Rhaphidhistia vermiculata, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. i, p. 140, pl. ix, figs. 15—19.
1883. — — *Hinde*. Cat. Foss. Sponges, p. 208.

Small, depressed convex, or irregularly rounded Sponges, apparently free. The type-specimen is 12 mm. in width. The fibres either anastomose irregularly, or in some specimens are vertical with transverse connections. At the surface they terminate in blunt conical processes. The fibres vary from ·67 to ·9 mm. in thickness. As in the preceding species they are solid, and are composed of straight and slightly curved spicules, which are interlaced with each other. A fairly long spicule measures ·3 mm.

The typical specimen described and figured by Mr. Carter, now in the collection of Mr. J. Thomson, who kindly forwarded it to me for examination, is depressed convex, with a flattened basal portion, which appears to me to be, in part at least, a fractured surface, but which Mr. Carter regards as a continuous membranous attachment, now lapidified. Mr. Carter further described the fibres as belonging probably to a fossil example of *Hydractinia* on which the Sponge was parasitic. It seems to me, however, more probable that, as in *H. Armstrongi*, the fibres of this species were throughout composed of interlacing acerate, siliceous spicules, which are now, with the exception of those weathered out on the surface, indistinguishably fused together. I do not think the fibres were originally hollow as stated by Mr. Carter; the cavities in them appear to result from erosion. The spicules in the type-specimen, as well as in others sent to me by Mr. J. Smith,

are but poorly preserved. I have been unable to detect any of a vermiform figure as represented by Mr. Carter.

This species differs from *H. Armstrongi* in its mode of growth, in the more robust character of the fibres, and in the somewhat greater thickness of the spicules.

Distribution.—Carboniferous: Upper part of Lower Limestone series; Cunningham Baidland, Law Quarry, Dalry, Ayrshire.

Sub-Order.—TETRACTINELLIDÆ.

Genus.—GEODITES, *Carter.*

1871. Annals and Mag. Nat. Hist., ser. 4, vol. vii, p. 129.

Generic Characters.—Sponges consisting of skeletal-spicules with bifid or trifid summit-rays and elongated shafts, and also of large acerate spicules and a dermal layer of minute globate or reniform spicules.

No formal definition of this genus was given by Mr. Carter, who proposed it to include detached spicules of the forms indicated, which are similar to those present in the existing genus, *Geodia*, Lam., and, with the exception of the dermal globular spicules, in *Stelletta*, Schmidt, and other allied genera. As the differences which characterise the recent genera of this group (of which *Geodia* may be accepted as the representative form) cannot be recognised in the detached fossil spicules, it seems preferable to adopt for them the common generic term proposed by Mr. Carter.

The acerate spicules in different species of this genus vary but little in form, and no satisfactory distinctions can be based on their relative proportions; but the characters of the bifid and trifid spicules appear to be sufficiently constant to permit specific distinctions to be based on them.

Owing to the fragile manner in which the spicules of this group of Sponges are held together by perishable spongin, it is extremely rare to find them in their natural positions in the fossil state, and their occurrence can only be recognised from the detached spicules. These make their first appearance in the Lower Carboniferous of Ayrshire; they occur also in the Lias of the Tyrol, and are extremely abundant in the Cretaceous strata of Britain and Germany.

30. Geodites antiquus, *Hinde*. Plate V, figs. 3, 3 *a*—3 *d*.

1883. Geodia ? antiqua, *Hinde*. Cat. Foss. Sponges, p. 208, pl. xxxviii, figs. 5, 5 *a*—5 *e*.

Detached bifid and trifid zone-spicules, with elongated, cylindrical, or sub-cylindrical shafts, and simple, short, obtusely-pointed head-rays, projecting obliquely forwards at angles between 45° and 52°. The shafts in all the spicules are incomplete, the longest fragment measures 2 mm.; they vary from ·15 to ·25 mm. in thickness. The spicular head-rays are about ·35 mm. in length. Detached acerate spicules occur in the same beds with the trifid spicules, and also in other beds in which no trifid forms have as yet been found. These acerates are fusiform, straight, or slightly curved, smooth, and pointed. Provisionally they may be regarded as belonging to the same species as the trifid forms. They vary from 2 mm. to 3·9 mm. in length and from ·1 to ·22 mm. in thickness.

Distribution.—Yoredale series: Harrogate, Richmond, Arkendale, Yorkshire; Halkin, Trelogan, Flintshire. Carboniferous Limestone: Clitheroe, Lancashire. Lower Limestone series; Low Baidland (J. Smith); Law Quarry, Dalry (J. Bennie). Upper Limestone series, Glencart, Dalry (J. R. S. Hunter, J. Smith).

31. Geodites deformis, *Hinde*, sp. nov. Plate V, figs. 4, 4 *a*—4 *g*.

This species includes very robust bifid and trifid zone-spicules, their shafts are straight or slightly curved, thickest near the summits, where they are slightly compressed; below the summits the shafts are circular in transverse sections. In several specimens the head of the shaft extends slightly beyond the point from whence the head-rays are given off (Plate V, 4 *f*), and there is usually a small central depression at the top of it. The spicular rays are relatively short, stout, conical, and obtusely pointed; they project obliquely forwards at angles varying between 45° and 70°. In the bifid spicules the head of the shaft is usually compressed and the rays are opposite to each other. The rays in the same spicule are apparently inequal in length; they range from ·7 to 1·4 mm. in length by ·4 mm. in thickness near their bases. The shafts in all the specimens yet discovered are broken and incomplete; they vary in thickness from ·6 to 1·05 mm.

Accompanying the bifid and trifid spicules are unusually robust, slightly curved, sub-cylindrical or fusiform spicules, with apparently rounded extremities,

which I regard as belonging to the same species. These spicules range from 2·5 mm. to 13 mm. in length, and from ·2 to 1 mm. in thickness.

At the time of writing the 'Cat. Fos. Sponges,' I had only seen two of the bifid zone-spicules, which I then thought might be distinct from *Geodia? antiqua;* the specimens which I have since received from Mr. John Smith confirm this opinion. The relatively large proportions and the general characters of these spicules readily distinguish them from any others of this sub-order, whether fossil or recent. The spicules are siliceous, and in the same condition of preservation as those of *Hyalostelia* with which they occur.

Distribution.—Carboniferous: Upper part of Lower Limestone series, Law Quarry, Dalry, Ayrshire (J. Smith, J. Bennie).

32. Geodites hastatus, *Hinde*, sp. nov. Plate IX, figs. 11, 11 *a*, *b*.

The distinctive zone-spicule of this species has a straight, gradually tapering shaft, and simple head-rays directed obliquely forwards at an angle of between 25° and 30° with the shaft. Associated in the same bed with the trifid spicules are numerous, more or less curved, acerate spicules, from 1·2 to 2 mm. in length, and from ·07 to ·15 mm. in thickness, which may be regarded as belonging to the same species. The head-rays of the trifid spicule are conical and pointed; they are ·25 mm. in length and nearly ·1 mm. wide at the base.

The disposition of the rays of the trifid spicule readily distinguish it from those of *G. antiquus;* it is also smaller, and the acerate spicules are likewise smaller than in the allied form.

These spicules are now of chalcedonic silica; they occur in thin layers of calcareous shale between massive beds of limestone. By dissolving the shale in acid they are obtained free from the matrix.

Distribution.—Carboniferous Limestone: Clitheroe, Lancashire.

33. Geodites cornutus, *Hinde*, sp. nov. Plate IX, figs. 12, 12 *a*—12 *e*.

The zone-spicule in this species has a straight, slender, gradually tapering shaft and simple head-rays, which spring nearly at right angles from the top of the shaft and curve backwards. This zone-spicule is accompanied by straight or slightly-curved, fusiform, acerate spicules from ·8 to 1·3 mm. in length, and from ·05 to ·07 mm. in thickness. In an adjoining locality a slender anchor-spicule

occurs, it has a conical head and simple rays directed backwards; the shaft is imperfect. This anchor is intermingled with acerate spicules similar to those occurring with the zone-spicule.

With the same forms of acerate spicules at Richmond, there are present one or two examples of kidney-shaped spicules similar to those of the dermal layer of the existing *Geodia*. They vary from ·13 to ·2 mm. in diameter. It is very doubtful if these really belong to the same Sponge as the zone, anchor, and acerate spicules, and they are but provisionally placed with them. These dermal spicules have not previously been found so low as the Carboniferous Rocks.

Distribution.—Yoredale series: Henblas, Trelogan, Flintshire; Richmond, Yorkshire.

34. Geodites simplex, *Hinde*, sp. nov. Plate IV, fig. 3.

1880. Acerate spicule of unknown Sponge, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, p. 212, pl. xiv, fig. 15.

Straight or curved acerate fusiform spicules, gradually tapering from the centre to acutely pointed extremities. They vary from ·55 to 1·4 mm. in length, and about ·1 mm. in thickness. No trifid or zone-spicules have as yet been found in the same beds with these acerates; but, judging by their form and proportions, it seems probable that they belong to a Sponge of this genus, and they are provisionally included in it for convenience of reference. Some of the forms were obtained by Mr. J. Wright from decayed chert, whilst others were found in a small hollow in a block of chert.

Distribution.—Carboniferous; Upper Limestone series, Ben Bulben, Sligo. Yoredale (?) series, Gwydfyd, Great Orme's Head, North Wales.

Genus—Pachastrella, *O. Schmidt.*

1868. Die Spongien der Küste von Algier, p. 15.

Syn.—Battersbya, *Bowerbank;* Dercitus, *Gray.*

Generic Characters.—Massive, nodose, platter-shaped, or irregularly expanded Sponges, without specialised dermal layer, frequently attached to and incrusting other Sponges. No special canals shown in fossil examples. The skeleton consists

mainly of four-rayed spicules, mingled loosely together without definite arrangement; acerate spicules are also present. The rays of the tetractinellid spicules may be either simple or furcate, equal or unequal in length; one ray may be developed so as to form an approximate shaft, or it may be reduced to a blunted knob or even disappear altogether. In some instances also, one ray is prolonged beyond the central point of junction, so that the spicule becomes five-rayed.

As the skeletal spicules in this genus are originally only held together by the soft perishable spongin, entire Sponges are of rare occurrence in the fossil state, and they have as yet only been met with in the Upper Chalk of Yorkshire and Germany. Detached spicules are, however, very abundant and widely distributed. They first appear in the Carboniferous strata of Ayrshire, and they also occur in the Lias, the Lower and Upper Greensand, the Chalk, and in the Eocene Tertiary. Throughout this series of rocks the spicules exhibit the same general characters as those of existing species of the genus.

35. PACHASTRELLA VETUSTA, *Hinde*. Plate V, figs. 5, 5 *a*—5 *c*.

1883. PACHASTRELLA VETUSTA, *Hinde*. Cat. Foss. Sponges, p. 209, pl. xxxviii, figs. 6, 6 *a*—6 *f*.

This species includes detached spicules of the normal four-rayed type, also spicules in which three or five rays are present. In the four-rayed spicules, three of the rays are nearly in the same plane, or form the outlines of a low, three-sided pyramid, whilst the fourth, or vertical ray, is usually shorter than the others. In some spicules the vertical ray is absent, whilst in others it is prolonged beyond the junction with the three rays, and the spicule is then five-rayed. The rays are straight or slightly curved, cylindrical or gradually tapering from the centre to the obtusely-pointed extremity; occasionally the ends are digitate. As a rule the rays in the same spicule are unequal in length. In a small specimen the rays are only ·54 mm. long by ·16 mm. in thickness, whilst in a single large specimen they measure 6 mm. by ·85 mm.

These spicules are of somewhat rare occurrence in the Dalry decayed chert, in association with the detached spicules of *Hyalostelia*, and they are in the same mineral condition as these latter. A few imperfect specimens, having the same characters as those from Dalry, but of much smaller proportions, are present in calcareous shale at Clitheroe.

Distribution.—Carboniferous: Upper part of Lower Limestone series, Cunningham Baidland, Law Quarry, Dalry, Ayrshire (J. Smith, J. Bennie). Carboniferous Limestone: Clitheroe, Lancashire.

36. Pachastrella humilis, *Hinde*. Plate IV, fig. 7.

1880. Quadriradiate spicule, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, p. 212, pl. xiv, fig. 17.

This name is proposed for detached four-rayed spicules of the normal type. The rays are simple, three of them are subequal in the same spicule, whilst the fourth or vertical ray is apparently shorter than the others. The rays are about ·3 mm. in length by ·07 mm. in thickness. These are more regular in form besides being distinctly smaller than those placed under *P. vetusta*, and they appear to indicate a distinct species. They are of rare occurrence in the decayed chert of Ben Bulben, and specimens in a fragmentary condition are present in the Sponge-beds at Halkin. In both these localities they are siliceous, and in the same mineral condition as the hexactinellid spicules intermingled with them.

Distribution.—Upper Limestones: Ben Bulben, Sligo (J. Wright). Yoredale Series: Henblas, Flintshire.

Sub-Order.—Lithistidæ.

Family.—Rhizomorina.

Genus.—Cnemidiastrum, *Zittel.*

1878. Studien über fossile Spongien. Zweite Abth. Abhandl. d. k. bayer. Akademie der Wissenschaften, Cl. ii, Bd. xiii, Abth. 1, p. 109.

Syn.—Cnemidium (in part); Achilleum (in part), *Goldfuss*, *Quenstedt;* Cnemispongia, *Quenstedt;* Cupulospongia (in part), *D'Orbigny;* Cnemiopelta, Cnemipsechia, Pachypsechia, ? Ceriopelta, Trachycinclis, *Pomel.*

Generic Characters.—Sponges for the most part simple, rarely compound, conical, cylindrical, turbinate, and vasiform, with thick walls and deep cloacal cavity. The walls are traversed by numerous vertical fissures, which towards the exterior bifurcate and anastomose with each other. These fissures consist of canals placed directly over one another and separated from each other by thin partitions of the spicular skeleton. A smooth dermal layer extends over both the outer and inner surface of the Sponge-wall, and the canal-apertures either project slightly above this layer or are in shallow depressions below it. The skeleton consists of moderately large spicules of curved irregular forms, branching at the

ends, and throughout covered with spinous projections, which frequently terminate in minute facets.

The examples of this genus have hitherto only been known from the Jurassic strata of Germany and Switzerland, but in the Carboniferous Limestones of Ireland, detached skeletal-spicules are present, which so closely resemble those of the typical forms of the genus that they may provisionally be referred to it.

37. CNEMIDIASTRUM PRISCUM, *Hinde*, sp. nov. Plate V, figs. 6, 6 *a*—6 *f*.

1880. LITHISTID (dendritically branched surface spicule), *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, p. 212, pl. xiv B, fig. 12.

This name is proposed for detached spicules of irregular forms, either curved, or variously branching, and terminating in small twig-like extensions. Minute spinous processes with facetted ends project from the surface of the spicules. The spicules vary from ·5 to ·8 mm. in length, and from ·075 to ·2 mm. in thickness.

These spicules are of not infrequent occurrence in the beds of decayed Carboniferous chert at Ben Bulben, associated with the spicules of *Spiractinella* and other hexactinellid and lithistid Sponges. As a rule they are quite detached from each other, but fragments of the skeleton occur in which two or three of the spicules are united together by the apposition of their spinous processes in the same manner as in the Jurassic examples of the genus.

Distribution.—Carboniferous Limestone: Ben Bulben, near Sligo, Ireland (J. Wright).

Family.—MEGAMORINA.

Genus.—DORYDERMA, *Zittel.*

1878. Studien über fossile Spongien. Zweite Abth. Abhandl. d. k. bayer. Akademie der Wissenschaften, Cl. ii, Bd. xiii, Abth. 1, p. 131.

Syn.—Spongia (in part), *Mantell, Phillips;* Spongites (in part), *Mantell;* Polyjerea (in part), *Roemer, Quenstedt;* Polypothecia (in part), *Benett.*

Generic Characters.—Sponges either simple or compound; cylindrical, pear-shaped, or dendriform, with cylindrical branches. The main body of the Sponge (and also the branches when present) is traversed longitudinally by parallel tubes

or canals opening at the truncated summit. Smaller canals extend radially from the surface towards the central axis. The skeleton is composed of relatively large, irregularly branching, spicules of great variety of form. The spicular branches are usually curved, simple, or bifurcated, and they either taper to an obtuse point or possess a flattened or slightly hollow facet at the extremity. These spicules are united either by the interlocking of the tapering branches, or by the close adpression of their facetted extremities to the rays of adjoining spicules, so as to form a somewhat coarse, open, irregular meshwork. The dermal layer consists of slender trifid spicules with elongated shafts, and small, simple, or compound head-rays. The shafts of these spicules are inserted in the mesh-apertures on the surface of the Sponge, whilst their head-rays slightly project outwards. Rarely, however, are the dermal spicules preserved *in situ*.

This genus makes its first appearance in the Carboniferous Rocks of Ayrshire, in which the characteristic skeletal spicules are found, but hitherto no entire Sponge; in the Lower and Upper Greensand and the Chalk the genus is abundantly represented.

38. Doryderma Dalryense, *Hinde*. Plate V, figs. 7, 7 *a*—7 *c*.

1883. Doryderma Dalryense (in part), *Hinde*. Cat. Foss. Sponges, p. 210, pl. xxxviii, figs. 7, 7 *a*—7 *d*; cet. excl.

The detached skeletal-spicules included in this species are more or less curved and irregularly branching, the branches are cylindrical in section and generally possess an elongate, concave, terminal expansion; in some examples the branches taper to an obtuse point. A fairly average spicule is 1 mm. in length and ·18 mm. in thickness.

These spicules are of rare occurrence in the same deposits in Ayrshire in which the detached spicules of *Hyalostelia* and other genera are abundant. In my original description of this species I included in it some smaller spicules from Ben Bulben, Sligo, but on further study I believe them to be quite distinct.

Distribution.—Carboniferous: Upper part of Lower Limestone series; Law Quarry, Dalry (J. Bennie). Upper Limestone series; Monkcastle, Kilwinning, Ayrshire (J. Smith).

Family.—ANOMOCLADINA.

Genus.—HINDIA, *Duncan*.

39. HINDIA PUMILA, *Hinde*, sp. nov. Plate V, figs. 8, 8 *a*—8 *f*.

1880. LITHISTID (? Tripod-like surface spicule of unknown species), *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, pl. xiv B, figs. 10, 11.
1883. DORYDERMA DALRYENSE (in part), *Hinde*. Cat. Foss. Sponges, p. 210, pl. xxxviii, figs. 7 *e*—7 *g*.

Entire Sponge unknown, the skeletal-spicules included in the species are, for the most part, tripodal in form, with a compressed triangular central node, from which three, short, cylindrical, straight or curved rays are given off. The rays terminate in flattened or concave, circular or ovate expansions. In some instances one of the rays furcates, so that the spicule consists of four rays. The central node is flattened or slightly convex above, and generally smooth and even, but in one specimen a small central wart is present. The spicular rays vary from ·2 to ·35 mm. in length by ·09 mm. in thickness.

In their peculiar tripodal form these spicules so closely resemble those of *Hindia fibrosa*, the typical species of the genus, that they may reasonably be included in it. They are, however, considerably larger than those of the type form, and further differ in the absence of the fourth or truncated ray, which in most, if not in all the spicules of *Hindia fibrosa*, projects upwards from the centre of the spicular node. It is possible that even in this latter species the fourth ray may be in some instances altogether suppressed, and its absence in these Carboniferous spicules is not sufficient to exclude them from the genus.

I had previously placed these detached spicules under *Doryderma*, but after seeing a larger series of them, and comparing them with the spicules of *Hindia fibrosa*, which I have lately obtained in a similarly detached condition, it seems preferable to remove them to the present genus. The spicules occur in the decayed chert of Ben Bulben, they are siliceous and in the same state of preservation as the hexactinellid spicules with which they are associated. Fragmentary spicules allied to the Ben Bulben forms, if not identical with them, are also present in the Sponge-beds at Richmond, Yorkshire.

Distribution.—Upper Limestones of the Carboniferous series; Ben Bulben, near Sligo, Ireland (J. Wright).

Sub-Order.—HEXACTINELLIDÆ.

Group.—LYSSAKINA.

Genus.—HYALOSTELIA, *Zittel.*

40. HYALOSTELIA SMITHII, *Young and Young* sp. Plate VI, figs. 1, 1 *a*—1 *l*, 2, 2 *a* —2 *k*.

1876. ACANTHOSPONGIA SMITHII, *Young and Young.* Cat. Western-Scottish Fossils, p. 38.
1876. HYALONEMA PARALLELUM, *Young* (non *M'Coy*). Ibid., p. 38.
1877. ACANTHOSPONGIA SMITHII, *Carter.* Ann. and Mag. Nat. Hist., ser. 4, vol. xx, p. 176.
1877. HYALONEMA — (in part), *Young and Young.* Ann. and Mag. Nat. Hist., vol. xx, p. 426, pl. xiv, figs. 1—3, 5—12, 14—17; pl. xv, fig. 30.
1877. ACANTHOSPONGIA — *Zittel.* Studien, Abth. 1, p. 60.
1878. HYALONEMA PARALLELA, *R. Etheridge, jun.* Geol. Mag., new ser., vol. v, p. 119.
1878. — SMITHII (in part), *Carter.* Ann. and Mag. Nat. Hist., ser. 5, vol. i, p. 129, pl. ix, figs. 1—9, 12, 13.
1878. HYALOSTELIA — *Zittel.* Handbuch der Pal., vol. i, p. 185.
1879. HYALONEMA — *Nicholson.* Man. of Pal., vol. i, p. 145.
1880. — ? GIRVANENSE, *Nich. and Ether., jun.* Mon. Silur. Foss. Girvan, Fas. ii, p. 239, pl. xix, figs. 1—1 *b*.
1880. ACANTHOSPONGIA SMITHII, *F. Roemer.* Lethæa Pal., p. 317.
1883. HYALOSTELIA — *Hinde.* Cat. Foss. Sponges, p. 150, pl. xxxii, figs. 1, 1 *a*—1 *g*.

Entire form of Sponge unknown; the portions preserved are fragments of the dermal layer with the spicules *in situ*, detached skeletal-spicules of various forms and dimensions, and bundles of elongated, rod-like spicules, and isolated fragments, forming the anchoring appendage of the Sponge.

The dermal layer of the Sponge consists of relatively large hexactinellid spicules in which the distal ray of the vertical axis is reduced to a small rounded knob or process, or is altogether wanting, whilst the transverse rays are of unusual length, and incline downwards from the central node (Pl. VI, fig. 1 *a*). These spicules are disposed so that their transverse rays overlap each other, and thus form quadrate interspaces which are partially filled by smaller spicules, whilst the

proximal ray of the vertical axis penetrated into the interior of the Sponge (Pl. VI, fig. 1).

The spicules of the body of the Sponge are regular and modified hexactinellids. In the simplest form, the rays are straight and gradually taper from the central node to an obtuse point; the vertical axis is also considerably longer than the transverse axes of the spicule. In other spicules the rays are very unequally developed, and sometimes curved. In some, probably abnormal, forms, five of the rays are reduced to small knobs. In other spicules the distal ray is not developed. There are great variations in the dimensions of the skeletal- and dermal-spicules. In small examples the principal axis is ·64 mm. in length by ·1 mm. in thickness, whilst the main axis in large forms attains to 9 mm. in length by ·54 mm. in thickness.

The spicular rods belonging to the anchoring appendage of the Sponge, occur either in detached fragments, or as broad compressed bands, in which the component rods are parallel to, and in contact with, each other. The rods are smooth, cylindrical, and with a well-developed axial canal, and not infrequently show traces of the concentric layers of which they are composed. In some, if not in all cases, the rods terminate in four short, blunted, more or less recurved rays (Pl. VI, figs. 2 *e*—2 *k*). No complete bundle of rods has been discovered; Messrs. Young have traced them to a length of 300 mm. (12 inches). The longest fragment which has come under my notice has a length of 170 mm. by 38 mm. in width, and from 5 to 10 mm. in thickness. There is also great variation in the size of the rods in the same bundle; the majority vary from ·95 to 1·35 mm. in diameter, but there are smaller ones intermingled, which are not more than ·15 mm. in thickness.

The skeletal-spicules of this species occur for the most part independently detached from each other, and mingled with spicules of other kinds of Sponges in beds of decayed chert in the Lower Carboniferous strata of Scotland, Yorkshire, North Wales, and Ireland. They also occur in close association with the ropes or bundles of anchoring-spicules, but not infrequently these latter are met with in beds which do not apparently contain the hexactinellid skeletal-spicules. This fact, however, may be explained by the greater chance of preservation of the anchoring-spicules owing to their penetration in the bottom ooze during the existence of the Sponge. It may be assumed that the anchoring and the skeletal-spicules belong to the same species. Further, the small fragments of the dermal layer of the Sponge which have been met with afford a clue to the character of the skeletal-spicules of the species, since they consist exclusively of simple and modified hexactinellids, and thus justify excluding therefrom those peculiar forms which were originally supposed to belong to this same species.

The spicules of this species in the decayed cherts and limestones of the West of Scotland are of a porcelain-white tint, the larger forms are opaque, but the smaller,

when mounted in Canada balsam, are translucent, and in some instances quite transparent. They are all siliceous, and the silica is either chalcedonic or crystalline. As a rule the axial canals are abnormally enlarged; in some cases the wall of the spicule is reduced to a thin crust inclosing the canal, and even this is occasionally destroyed, and merely the solid infilling of the canal remains. The anchoring-rods have precisely the same appearance, and are in the same state of preservation as the skeletal-spicules. The anchoring-spicules occurring in the Yoredale rocks at Richmond, Yorkshire, have a translucent, horny aspect; they consist of chalcedonic silica.

This species is very abundant and widely distributed in the Lower Carboniferous of Scotland, and in the cherts and limestones of the Yoredale series of Yorkshire. In some places beds of rock, six inches (·015 m.) in thickness, are made up of bands of the anchoring-spicules crossing over each other in a generally horizontal direction, and it is probable that many of the Sponge-beds, mentioned in the Introduction, principally consist of the detached spicules of this species. As already mentioned, some of the anchoring-spicules are met with in the Ordovician strata of Girvan, Ayrshire. This species may be distinguished from *Hyalostelia parallela*, M'Coy sp., by the much more robust character of the spicular rods.

Distribution.—Carboniferous, Yoredale series: Yorkshire,—Richmond, Arkendale, near Muker; Gunnerside Gill, Swinner Gill, Sargill Beck, and throughout Swaledale generally, where the main chert crops out. Flintshire,—Halkin, Henblas, near Holywell.

Scotland.—Upper part of Lower Limestone series: Cunningham Baidland, Low Baidland, Auchenskeith, Thirdpart, Hourat, Law, Birkhead, Blackstone, Dalry. Upper Limestone series: Linn Spout, Glencart, Lambridden, Dalry, Ayrshire; Gateside, Beith; Brockley, Lesmahagow; Ponniel Water, Douglas. Messrs Young cite also the following localities: Dockra, Hillhead and Trearne quarries, near Beith; Waterland Quarry, Dunlop, Ayrshire; Corrieburn, Campsie Hills, Bathgate, Chapel Quarry, near Kirkaldy, Fifeshire. Mr. R. Etheridge, junr., also records this species from Petershill and Galabraes quarries, near Bathgate; Tartraven old quarry, near Linlithgow; Charlestown Quarry, near Inverkeithing; Roscobie Quarry, near Dunfermline; Laddedie Quarry, near Cupar; Airfield, near Cousland, by Dalkeith.

Ireland.—Calp series: Bundoran, Co. Leitrim, Tyrone. Upper Limestone series: Ben Bulben, near Sligo.

41. Hyalostelia parallela, *M'Coy* sp. Plate VI, figs. 3, 3 *a*—3 *g*.

1844. Serpula parallela, *M'Coy*. Synop. Carb. Foss. Ireland, p. 169, pl. xxiii, fig. 30.
1843. — socialis, *Portlock* (non *Goldfuss*). Geol. Report Londonderry, p. 362, pl. xxv a, figs. 9 *a*, 9 *b*.
1854. — parallela, *Morris*. Cat. Brit. Foss., p. 92.
1866. Hyalonema parallelum, *Suess*. Ann. and Mag. Nat. Hist., ser. 3, vol. xviii, p. 404.
1878. — Youngi ?, *R. Etheridge, jun.* Geol. Mag., vol. v, p. 119.
1880. Acestra parallela, *F. Roemer*. Lethæa Pal., p. 318, fig. 60.
1880. Sarcohexactinellid, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, p. 211, pl. xiv b, figs. 8, 9.
1881. Acestra parallela, *Nathorst*. Om spår af några evertebrade djûr., Kong. Svenska. vetensk. Akad. Handl., Bd. 18, No. 7, p. 46.
1883. Hyalostelia — *Hinde*. Cat. Foss. Sponges, p. 151.

This species includes simple and modified hexactinellid spicules, probably belonging to the body-skeleton and the dermal layer, together with fragments of the spicular bundles, and detached rod-like spicules, forming the anchoring appendages of the Sponge. In the spicules of the dermal layer only five rays are present, the distal ray not being developed. The transverse rays are straight or slightly curved, nearly cylindrical, or but slightly tapering, and terminate obtusely. The rays vary from ·45 to 1·5 mm. in length, and from ·1 to ·25 in thickness. The spicules are siliceous, and in some specimens the canals are preserved.

The elongated spicular rods of the anchoring-rope of the Sponge have smooth, even surfaces, and appear to be cylindrical. Near the distal ends they slightly expand, and they terminate in conical extremities with four short, stout, recurved points or rays. The canals in these spicular rods are usually preserved, and in some instances the concentric layers can be seen (Pl. VI, fig. 3 *f*). As a rule they are now of chalcedonic silica, but in some cases the silica has been replaced by calcite. The anchoring-spicules sometimes occur detached from each other, and widely spread out on the surface of the rock; not unfrequently they are grouped into compressed bundles of 5 to 9 mm. in width, in which the component spicules are nearly in contact and disposed parallel to each other. Fragments of these bundles or ropes occur, having a length of 140 mm. The individual rods in the same bundle exhibit considerable variation in size; they range from ·05 to ·5 mm. in thickness.

This species was originally proposed by Portlock for narrow bands or bundles of

the anchoring-spicules on a slab of dark limestone, which he regarded as identical with the groups of annelid tubes described by Goldfuss as *Serpula socialis.* Subsequently M'Coy disputed the identity of the specimens with Goldfuss's species; but, accepting their annelidan characters, changed the name to *Serpula parallela.* Professor Suess of Vienna appears to have first called attention to the real character of the spicular bundles, by comparing them to the anchoring-ropes of the recent *Hyalonema.*

Hitherto only the bands of anchoring spicules have been included in this species, but I have discovered on the slab of limestone containing Portlock's typical anchoring-spicules, a single modified hexactinellid spicule of the same character as those discovered by Mr. J. Wright, associated with the anchoring-spicules in the decayed chert of Ben Bulben; and there seems, therefore, good reason to suppose that these five-rayed dermal spicules belong to the same Sponge as the anchoring-spicules.

This species differs from *Hyalostelia Smithii*, not only in the form of the dermal spicules, but the anchoring-spicules are considerably smaller. Whilst in *H. Smithii* the majority of the spicules range from ·7 to 1·4 mm. in thickness, in the present species they seldom exceed ·5 mm. in thickness. They closely correspond in size with *H. fasciculus*, M'Coy sp., but in no instance have I seen any of the transverse rods or frills which characterise this latter species.

Distribution.—Carboniferous Limestone: Clitheroe, Lancashire; Yoredale series, Gunnerside Gill, Muker, Richmond, Yorkshire; Henblas, Gwydfyd, Great Ormes' Head, North Wales.

Scotland.—Beith, Ayrshire; Hillhead and Whitfield quarries, near Macbiehill Station, Peebles; shale above No. 1 Limestone (R. Etheridge, junr.).

Ireland.—Calp or Middle Limestones: Ballinhillick, Bundoran, Co. Leitrim; Clogher, Tyrone. Upper Limestones: Ben Bulben, near Sligo.

Genus.—Holasterella, *Carter*, emend. *Hinde.*

1879. Ann. and Mag. Nat. Hist., ser. 5, vol. iii, p. 141.

Generic Characters.—Massive club-shaped Sponges, supported on a sub-cylindrical stem. The body of the Sponge apparently traversed longitudinally by sinuous canals. The skeleton consists of comparatively large, regular, hexactinellid and other spicules, mingled with smaller stellate and globostellate forms. The larger spicules are disposed irregularly; some of their rays appear to be partially fused with those of adjoining spicules, probably resulting from fossilization, whilst

the stellate spicules fill the interspaces between the rays of the larger; they also line the canals, and apparently cover the surface of the Sponge.

Mr. Carter did not give a diagnosis of this genus apart from the characters of the typical species *H. conferta*. I have prepared that given above from a study of the type specimen described by Mr. Carter, and now in the possession of Mr. J. Thomson of Glasgow; and Mr. Carter kindly supplied me with some detached fragments from it.

The type-specimen is in a very unfavorable condition of preservation, and the characters of many of its component spicules cannot be ascertained with certainty. The larger spicules are so fused and intermingled together that no complete forms are exposed to view; there is no doubt, however, that some are normal hexactinellid spicules, with smooth, tapering rays, whilst others, judging from fragments, are peculiar forms with curved and spinous rays. The minute stellate spicules of the surface, and lining the canals of the Sponge, have from six to fifteen rays radiating from a thickened centre. It seems highly probable that the stellates with more than six rays may be merely modified hexactinellid spicules in which furcation has taken place in one or more of the normal rays. Owing to their small size, and their present condition, the central portion of these spicules is not clearly shown.

The *larger* spicules, which Mr. Carter has described and figured as belonging to the type specimen, were not obtained from it, but they were detached spicules, and it is uncertain if they were derived from the same locality as the Sponge itself. Mr. Carter regarded these detached spicules (*l. c.*, pl. xxi, figs. 4, 5, 7) as identical with those forming the interior portion of the skeleton of the Sponge, but after careful examination of the original specimen, I am unable to agree with this conclusion. The larger spicules in it are to a large extent concealed and obliterated; but, judging from the portions remaining, they appear to me to be quite distinct from the "double stelliform nail-like spicules," originally figured by Mr. Carter as doubtfully belonging to *Hyalonema Smithii* ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. i, p. 133, pl. ix, fig. 11).

As this genus is, in part at least, composed of normal hexactinellid spicules, its systematic position appears to me to be in the Lyssakine group of the Hexactinellidæ. Mr. Carter, however, regards it as the type of a new group, 'Holasterellina,' among the Suberitida, thus belonging to his Holorhaphidota (= Monactinellidæ).

Only the typical species *H. conferta* can, in my opinion, properly be included in the genus; the other species which by Mr. Carter and myself (before that I had seen the original specimen) have been referred to it, I propose to place in distinct genera.

42. HOLASTERELLA CONFERTA, *Carter*. Plate VIII, figs. 2, 2 *a*—2 *g*.

1879. HOLASTERELLA CONFERTA, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. iii, p. 141, pl. xxi, figs. 1, 2, 8, cet. excl.
1883. *Non* — — *Hinde*. Cat. Foss. Sponges, p. 152, pl. xxxii, figs. 2—2 *f*.

The typical example of the species is a club-shaped Sponge, about 165 mm. in height by 50 mm. in extreme width. It gradually increases in thickness from its base to the rounded summit. The Sponge is broken into several pieces, and its form is to such an extent enveloped and concealed by the matrix, that I have not attempted to figure its outline.

The canals which apparently traverse the Sponge longitudinally are sinuous in their course, and from ·5 to ·8 mm. in width. The surface of the Sponge is also excavated by numerous ovoid or wedge-shaped pits from 1 to 1·5 mm. in length; some of these extend but a short distance into the Sponge, and exhibit smooth sides. They are regarded by Mr. Carter as the burrows of crustaceans.

The minute stellate and globo-stellate spicules occur in small groups on the surface, and in the interior of the Sponge; their rays terminate obtusely. They have an average diameter, including the rays, of ·3 mm. The rays of the smaller hexactinellid spicules, which partly compose the body of the Sponge, are about ·3 mm. in length; whilst in some of the larger spicules, which are only partially shown, the rays reach to 2·3 mm. in length by ·3 mm. in thickness. The spicules and fragments figured on Pl. VIII, figs. 2—2 *g* are drawn from the type-specimens forwarded to me by Mr. J. Thomson and by Mr. Carter, and they are the most perfect which could be found in them.

Distribution.—Carboniferous: highest beds of Upper Limestone of the South-west of Scotland, near Glasgow (J. Thomson).

Genus.[1]—SPIRACTINELLA, *Hinde*, gen. nov.

Syn.—Holasterella (in part), *Carter*, *Hinde*.

Form of Sponge unknown, it is composed of simple hexactinellid spicules, and forms derived from them, which apparently were quite free from each other, and merely held in position by the soft structures of the Sponge. The simple hexac-

[1] Σπεῖρα, anything wound round; ἀκτίν, ray, dimin.

tinellid spicules have tapering, pointed rays; in the modified compound forms the rays are once, or oftener furcate, so that in certain examples they resemble stellate spicules. The surface of the rays of both the larger and smaller spicules consists of a spiral ridge extending from their bases to their tips. In the bases of the larger spicular rays the ridge is broken up into a series of ellipsoidal nodes.

I propose this genus to include the forms placed by Mr. H. J. Carter, F.R.S., in *Holasterella Wrightii.* The spicules so markedly differ from those of the type form of *Holasterella*, as far as these latter can be ascertained, that they may be regarded as belonging to a distinct genus. In the simplest spicules there are six straight, pointed rays at right angles to each other, and their surfaces are ornamented with a continuous spiral ridge or coil; in some of the compound forms the rays bifurcate equally near their bases, and the spicules then consist of twelve sub-equal rays. Most of the larger spicules are of this type. In the more complex stellate spicules the primary six rays appear to be always present, but they divide and subdivide near their bases somewhat irregularly, so that from each primary ray three, four, five, and even six rays are given off in such a manner that the spicule has a star-like form, and consists of a variable number of rays, ranging from twelve to thirty-six.

The spicules of this genus are characterised not only by their spiral coil, but by the furcation of the rays of the larger skeletal-spicules as well as of the smaller stellates. Only a single species is at present known, and this was discovered by Mr. J. Wright, F.G.S., in decayed chert of Carboniferous age.

43. Spiractinella Wrightii, *Carter* sp. Plate VIII, figs. 1, 1 *a*—1 *h*.

1880. Holasterella Wrightii, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. vi, pl. xiv B, figs. 1—7.
1883. — — *Hinde*. Cat. Foss. Sponges, p. 153, pl. xxxii, figs. 4—4 *f*.

The character of the spicules has already been stated in the definition of the genus. In the larger spicules the rays do not appear to divide more than once, they diverge from each other near the base of the simple ray at an angle between 70° and 80°. No complete large spicule has yet been met with; judging from imperfect specimens all the rays appear to have been furcate. The secondary rays of these larger spicules attain in some cases a length of 2 mm. by ·5 mm. in thickness. The spicules with six simple rays appear to be all of intermediate size, in these the vertical axis is usually longer and more tapering than the transverse axes; in an average form the longer axis measures 1·2 mm. by ·15 mm. in thickness. The

so-called stellate spicules are all of small dimensions, they vary from ·3 to ·67 mm. in diameter. In some the primary six rays simply bifurcate, in others one or more of the primary rays give off at their bases three or even four secondary rays, and these may also subdivide. The smaller rays of these stellates seem to have all originally possessed a spiral coil in the same manner as the larger, though it is now scarcely perceptible.

These various forms of spicules were met with quite detached from each other in a bed of decayed chert, but there can hardly remain a doubt that they belonged to the same species. The spicules are now of chalcedonic and crystalline silica, they are of a creamy-white tint by reflected light, and translucent when examined in Canada balsam. Only rarely can the axial canals be detected. I am indebted to Mr. H. J. Carter, F.R.S., and to Mr. J. Wright, F.G.S., for the opportunity of studying the type-specimens.

Distribution.—Carboniferous Limestone: Upper series, Ben Bulben, near Sligo, Ireland.

Genus.—ACANTHACTINELLA,[1] *Hinde*, gen. nov.

Syn.—Holasterella (in part), *Hinde.*

Form of Sponge unknown; the skeleton consists of relatively large spicules of very varied and aberrant forms, but apparently modifications of the hexactinellid type. In the simplest form there are only four rays in one plane at right angles to each other, in others, five rays are present, whilst other forms possess six rays. The rays may be straight or curved, sub-cylindrical or compressed. They frequently bifurcate near their ends, and give off irregularly, spinous processes, so that the extreme varieties are altogether abnormal in appearance. The spicules frequently exhibit wide canals; they are now of granular silica of a brownish tint.

The spicules for which I propose this genus, differ very considerably in form and structure from any other detached Sponge-remains mingled in the same deposits with them.

In many of them the number and arrangement of the rays appear to be indefinite, and they do not exhibit any regular plan of structure. In others, however, the primary rays are disposed like those of normal hexactinellid spicules; but, owing to the irregular development of spines and the subdivision of the rays themselves, their typical character is largely masked. Further, their peculiar granular structure, and the large and often hollow interior canals, contrast very greatly with those of the other Sponge-spicules preserved with them under similar conditions, and seem

[1] ἄκανθα, a thorn; ἀκτίν, a ray, dimin.

to point to fundamental differences in their nature. These peculiar features suggested to Mr. J. Young that they might have been produced by an incrustation over other Sponge-remains; but since no other spicules yet found in these beds present the same remarkable forms, it can hardly be assumed that they have originated in this manner.

These spicules appear to belong to a single species; they have as yet only been met with in the Carboniferous deposits of Ayrshire.

44. Acanthactinella Benniei, *Hinde*. Plate VIII, figs. 4, 4 *a*—4 *i*.

1883. Holasterella Benniei, *Hinde*. Cat. Foss. Sponges, p. 153, pl. xxxii, figs. 5—5 *e*.

1877. Incrusting Sponge?, *Young and Young*. Ann. and Mag. Nat. Hist., vol. xx, p. 429, pl. xv, fig. 41.

The characters of the species have been enumerated in the description of the genus. Usually the rays bifurcate near their extremities, but not infrequently there is a tripartite division. The rays terminate obtusely. As a rule the spicules are entirely detached, but in one or two cases a fusion of the principal axes of two spicules has taken place so that they now appear as one (Pl. VIII, fig. 4 *d*). The axes of the spicules vary from 2·5 to 4 mm. in length, and the rays are from ·5 to ·9 mm. in thickness.

In my original description, this form was placed in the genus *Holasterella*, but its characters now seem to me to be at least generically distinct.

Distribution.—Carboniferous: Upper part of Lower-Limestone series, Cunningham Baidland, Low Baidland, Law, Dalry, Ayrshire. (J. Bennie, J. Smith, J. Young.)

Flesh-spicules of Hexactinellids. Plate IX, figs. 13, 13 *a*.

In microscopic sections of the chert Sponge-beds of Yorkshire, I have recently found two distinct forms of flesh-spicules, which I am at present unable to place with any of the skeletal-spicules previously described. One form (fig. 13) is a regular six-rayed spicule, the rays are sub-equal, tapering, and furnished with blunt spines projecting at right angles from their surfaces. This spicule is ·23 mm. in its longest axis, and the rays are ·02 mm. in thickness. It is present in the Yoredale-beds at Richmond.

The other spicule (fig. 13 *a*) is a six-rayed form, in which each of the principal

rays, at a short distance from the central axis, divides into three secondary pointed tapering rays. The diameter of this form is ·4 mm., and the thickness of the rays near the centre is ·04 mm. These spicules are very unfavorably preserved; they are not uncommon in a boulder of chert from the Drift at York, associated with spicules of *Reniera* and other forms like those in the chert-beds at Richmond; it is, therefore, probable that it may originally have been derived from this neighbourhood. A flesh-spicule of a nearly similar form, but of very much smaller proportions, has been figured by Dr. Bowerbank from *Euplectella aspergillum*, Owen.[1]

Sub-Order.—Heteractinellidæ.

Genus.—Tholiasterella,[2] *Hinde*, gen. nov.

Syn.—Holasterella (in part), *Hinde;* ? Hyalonema (in part), *Carter.*

Form of Sponge unknown; the skeleton consists of spicules, which, as suggested by Mr. Carter, bear a general resemblance to the handle and ribs of an umbrella. The handle or vertical ray of the spicule supports on its summit a variable number of rays which radiate from it in a generally horizontal direction. A central disc of variable proportions is formed by the union of the bases of the horizontal rays and the upper surface of this, and of the rays, may be either smooth or covered with tubercles or blunted vertical spines. In some cases spicules of an irregular form are present, in addition to the normal umbrella-spicules.

The spicules of the body of the Sponge appear to have been aggregated together without definite arrangement; they seem to have been mostly free from each other, and merely held in position by the interlacing of their rays; but in some cases the rays appear to have been partially cemented together. The outer surface or dermal layer of the Sponge consisted of a framework with irregular interspaces, formed by the intervening and partial fusion of the horizontal rays of larger and smaller "umbrella" spicules, whilst the shafts of these spicules penetrated into the interior of the Sponge.

The spicules on which this genus is based were recognised both by Messrs. J. and J. Young and by Mr. Carter, and in the 'Cat. Foss. Sponges' I described them as a species of *Holasterella*.

Since then Mr. James Bennie, Mr. John Smith, and also Mr. John Young, have supplied me not only with many fresh examples of detached spicules, but with fragments of the skeletal-structure in which the spicules are in their original

[1] 'Mon. of the Brit. Spongiadæ,' vol. i, p. 258, pl. viii, fig. 189.

[2] θολία, a hat to keep the sun off, a parasol; ἀστήρ, a star, dimin.

positions. These fragments are built up nearly exclusively of the umbrella spicules, and they thus clearly show that we are dealing with a genus of Sponges fundamentally distinct in the character of their component spicules from those of *Holasterella* and *Asteractinella*. One distinguishing feature of the genus is the continuous character of the dermal layer, the rays of the larger spicules in it being generally fused and amalgamated together. On the other hand, the number and complete forms of the detached spicules present in the same deposits with the portions of the dermal layer, indicate that the majority of the spicules forming the interior skeleton of the Sponge were only held together by the soft animal structures of the organism.

The spicules of this genus do not show any derivation from normal hexactinellid spicules. The number of the transverse or horizontal rays varies from five to nine, and as these are apparently equally developed, and radiate at equal angles from the centre, there is no room for supposing that they result from a modification of the four transverse rays of the typical hexactinellid spicule. On the other hand, the inconstancy in the number of the rays, as well as the general characters of the spicules, and their union together (in the dermal layer) separate them very decidedly from the spicules of *Astræospongia*.

The spicules of this genus are siliceous and in a similar condition of preservation as those of *Hyalostelia* and other siliceous Sponges in the same deposit.

Four species can be recognised in the Carboniferous strata of Ayrshire, and one of these also occurs in Germany. The genus does not apparently pass higher than the Carboniferous.

45. Tholiasterella Youngi, *Hinde*. Plate VII, figs. 2, 2 *a*—2 *f*.

1883. Holasterella Youngi, *Hinde*. Cat. Foss. Sponges, p. 152, pl. xxxii, figs. 3—3 *d*.
1877. Stellate spicules, *Young and Young*. Ann. and Mag. Nat. Hist., ser. 4, vol. xx, p. 420, pl. xiv, figs. 13, 19, 24, 27, 29.
1878. Hyalonema Smithii? (in part), *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. i, p. 133, pl. ix, fig. 10.
1880. Hyalostelia Smithi, *Steinmann*. Zeitschr. d. deutsch. geol. Gesell., p. 395, pl. xix, fig. 5.

The skeletal-spicules included in this species have stout, straight, conical shafts, and from five to nine transverse rays, which may be either horizontal or slightly incurved. There is a well-marked central disc to the spicules, and its upper

surface is usually covered by numerous tubercles or blunt spines, which also extend over the proximal upper portion of the rays; in some cases the summit is smooth, whilst the under or inner surface of the disc and rays is always smooth and even. The transverse rays are compressed and sub-equal, they gradually taper to a blunted extremity. The transverse rays of the dermal spicules are partially fused together. There is considerable variation in the dimensions of the spicules. A fairly large example is 4·3 mm. in width across the summit, and the individual rays are about 2 mm in length, and about ·7 mm. in width at the base. A small spicule, on the other hand, is only 1·5 mm. across the summit, and the separate rays are ·7 mm. in length by ·15 mm. in thickness. The average number of the transverse rays is seven.

This species differs from *T. gracilis* in the greater development of the central disc, the distinct conical form, and more robust character of the transverse rays of the spicules. These features are shown alike in the fragments of the dermal layer and in the detached spicules.

Distribution.—Carboniferous: Upper part of Lower-Limestone series, Law, Low Baidland; Thirdpart, Glencart, Waterland, Dalry. Lower part of Upper Limestone series, Monkcastle Glen, Kilwinning, Ayrshire. (J. Young, J. Smith, J. Bennie.)

Also in bed of dark, pyritous shale in the Carboniferous Limestone of Ratingen, near Dusseldorf. (Steinmann.)

46. THOLIASTERELLA GRACILIS, *Hinde*, sp. nov. Plate VII, figs. 1, 1 *a*—1 *g*.

The spicules of this species possess an elongate shaft, a central disc of moderate dimensions, and from six to eight transverse rays. These are straight or curved, circular or elliptical in section, and they gradually taper to an obtuse point. The upper surface of the central disc is furnished with prominent blunted spines, and in the spicules of the dermal layer there are obliquely-directed spines which form notches, into which the rays of adjoining spicules are closely fitted. In some instances also the rays are notched or furcated at their extremities (Pl. VII, fig. 1 *b*).

The dermal layer, as in the preceding species, is formed by the partial fusion and interlacing of large and small spicules.

In a large spicule the entire breadth of the summit is 5 mm., and the rays at the base are ·4 mm. in thickness. The breadth of a small spicule is 1·8 mm., and the rays are ·2 mm. in thickness. The average number of the transverse rays is six.

This species is mainly distinguished from *T. Youngi* by the more elongated

and cylindrical form of the spicular rays and the less development of the central disc.

Distribution.—Carboniferous: Upper part of the Lower Limestone series, Law, Low Baidland, Dalry, Ayrshire. (J. Smith, J. Bennie.)

47. Tholiasterella compacta, *Hinde*, sp. nov. Plate VII, figs. 3, 3 *a*.

The dermal skeleton of this species is a thick, perforated plate, consisting of "umbrella-" shaped spicules, with stout conical shafts, and five or six robust, cylindrical transverse rays. These completely fuse and amalgamate with those of adjoining spicules, and they are so closely arranged that only a few small circular or oval apertures are present between the rays. The upper surface of the spicule, forming the exposed surface of the dermal layer, is thickly covered with numerous minute, blunted tubercles.

This perforated dermal layer is from 1 mm. to 1·3 mm. in thickness, whilst the entering shafts of the spicules in some instances are ·3 mm. in length. In a specimen belonging to Mr. John Smith, a portion of the internal skeleton is preserved in connection with the dermal layer. It apparently consists of relatively large spicules of an irregularly stellate form, the rays are of unequal length, conical, and often furcate at their ends. These spicules are intermingled together without definite arrangement, and the rays are frequently fused at their points of contact with adjoining spicules.

The complete fusion of the spicules of the dermal layer, and the irregular form of the skeletal-spicules, distinguish this from other species of the genus.

Distribution.—Carboniferous: Upper part of Lower-Limestone series, Cunningham Baidland, Law Quarry, Dalry, Ayrshire. (J. Bennie, J. Smith.)

48. Tholiasterella crassa, *Hinde*, sp. nov. Plate VIII, figs. 5, 5 *a*; Plate IX, figs. 2, 2 *a*—2 *b*.

Skeleton consisting of very robust "umbrella" spicules, with conical or elongate cylindrical shaft, and from five to six transverse rays. These rays are cylindrical or conical, straight or curved, horizontal or diverging irregularly from the central disc. As a rule the transverse rays are very unequally developed, some being mere conical points, whilst others in the same spicule are relatively very long. The rays are smooth, and either simple, or with stout, obliquely placed spines,

which serve as notches, in which adjoining rays are held in position. In addition to the normal-umbrella spicules there are anomalous forms consisting of five or six unequal rays diverging irregularly from a common centre. In these it is difficult to recognise either the shaft or the transverse rays of the normal spicules. The spicules are irregularly intermingled together, the smaller forms in the interspaces between the larger. At their points of contact the rays are frequently firmly fused together; this fusion is evidently of natural origin, and not produced by secondary fossilization. The connected skeleton is thus of an intricate, confused character, in which it is not always easy to trace the individual spicules.

In a large spicule a single ray is 4·6 mm. in length, and 1·3 mm. in thickness at its base; the rays of smaller forms are about 1 mm. in length.

This species is based on a fragment of the connected skeleton, in which the spicules retain their original arrangement, as well as on detached spicules. It is characterised by the relatively large size and the irregular development of the spicules. The dermal layer is not yet known. The form appears to be rare, and limited in its distribution.

Distribution.—Carboniferous. Lower part of Lower-Limestone series, Crawfield Quarry, Beith, Ayrshire (J. Young).

Genus.—ASTERACTINELLA.[1]—*Hinde*, gen. nov.

Syn.—Holasterella (in part), *Carter*, *Hinde*. Hyalonema (in part), *Young and Young*.

Form of entire Sponge unknown, the skeleton consists of relatively large spicules, in which a variable number of unequal rays radiate from a common centre in different directions. The simplest form of these spicules has a principal vertical axis, and from six to fourteen rays diverging from the centre at varying angles. In another form one ray is conspicuously larger than the others, which radiate star-like from its summit. In others the rays are subequal. The most complex form consists of a number of rays extending from a common centre in a generally horizontal direction; the proximal portion of these rays coalesces together, so that the upper surface of the spicule has the appearance of the extended corolla of a flower, whilst beneath this are three or four robust divergent rays (Pl. VIII, figs. 3 *e*, 3 *f*). Smaller spicules in which numerous simple blunt rays diverge from a centre also probably belong to this genus. These various forms of spicules appear to have been irregularly intermingled together to form the skeleton. A few fragments have been found in which the rays of adjoining spicules are now

[1] ἀστήρ, star; ἀκτίν, ray, dimin.

partially fused together, but this probably arises from the fossilization; the numerous instances in which the spicules are now entirely free seem to indicate that they were originally only held together by the soft structures of the Sponge.

The character of these spicules clearly distinguishes them from the other detached forms with which they are associated; and the occurrence of fragments of the Sponge-skeleton exclusively composed of them likewise shows that they are distinct. No trace of any derivation from the hexactinellid type is perceptible in any of these spicules; even in the simplest form more than six rays are present, and there is no indication that they may have originated from the subdivision of the rays of a normal hexactinellid spicule.

Some of the spicules included in this genus were referred by Mr. Carter to *Holasterella conferta*, and relying on his definition I likewise relegated them to the same species in the 'Cat. Foss. Sponges;' but, as already mentioned, in a subsequent examination of the type form I have been unable to discover any of these forms in it.

Two species of this genus have been recognised in the Carboniferous strata of Ayrshire.

49. Asteractinella expansa, *Hinde*, sp. nov. Plate VIII, figs. 3, 3 *a*—3 *h*.

1877. Hyalonema Smithii (in part), *Young and Young*. Ann. and Mag. Nat. Hist., ser. 4, vol. xx, pl. xiv, figs. 20, 21.

1878. — — ? (in part), *Carter*. Ann. and Mag Nat. Hist., ser. 5, vol. i, p. 133, pl. ix, fig. 11.

1879. Holasterella conferta (in part), *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. iii, p. 141, pl. xxi, figs. 4, 5, 7, cet. excl.

1883. — — *Hinde*. Cat. Foss. Sponges, p. 152, pl. xxxii, figs. 2—2 *f*.

In the simpler spicules there is a prominent vertical ray, from the summit of which nine to twelve robust rays diverge at various angles; a variable number of small conical rays are also frequently present. In other spicules there is a distinct vertical axis, whilst not infrequently no distinct vertical ray or axis is present, and the spicule consists of seven to twelve rays of varying lengths in addition to several subordinate conical rays, all radiating from a common centre. The rays are straight or slightly curved, circular in transverse section, and they gradually taper to an obtuse point. The smaller central rays are sometimes divided at their tips. In a small spicule the principal rays are ·65 mm. in length and ·125 mm.

in thickness, whilst in a large one they reach a length of 3 mm. by ·6 mm. in thickness.

In the complex corolla-like spicules the number of horizontal rays varies from eighteen to thirty, they are in close contact, and apparently amalgamated laterally for about half their length, and thus form a platter-shaped central depressed disc. The upper surface of the ray is usually covered with minute conical tubercles, which in some cases have the appearance of secondary rays. The corolla-like summit of the spicule, which ranges from 1·6 to 4 mm. in breadth, is supported on three to five stout conical rays, which appear to have extended into the interior of the Sponge, whilst the expanded summits formed the surface-layer of the Sponge. In addition to the larger spicules there are also small subspherical spicules, consisting of numerous minute, obtusely-pointed, subequal rays, nearly in contact with each other.

The spicules are siliceous, and exhibit the same appearance as those of *Hyalostelia* and other siliceous Sponges in the same deposits. In no case have I been able to recognise axial canals in them.

The spicules in these species are distinguished from those of *A. tumida* by the more elongated character of the rays as well as by differences of form.

Distribution.—Carboniferous: Upper part of the Lower-Limestone series, Law, Blackstone, Waterland, Dalry, Ayrshire. (J. Smith, J. Bennie, J. Young.)

50. Asteractinella tumida, *Hinde*, sp. nov. Plate IX, figs. 1, 1 *a*—1 *g*.

The simpler spicules of this species are star-like in form, consisting of from five to nine subequal, relatively short, very stout simple conical rays, radiating from a common centre. In the more complex forms, the longer rays are supplemented by a group of small conical rays in the central portion of the spicule, which are frequently subdivided at their summits. Spicules with vertical axes are also present as well as corolla-like spicules of the same general form as in the preceding species, but with more conical rays. The spicules included in this species vary considerably in size. The star-like forms are from 2 to 3·5 mm. in diameter, and the rays are ·85 mm. in thickness at their bases. In contrast with the larger forms, the smaller spicules are only ·45 mm. in extension, and the rays are not more than ·1 mm. in thickness.

The spicules of this species are characterised by the conical robust form of their rays. In fragmentary portions of the skeleton which have been found, the larger and smaller spicules are intermingled, and their rays are partially fused together, but the greater proportion of the spicules are now quite free from each other.

Distribution.—Carboniferous : Upper part of the Lower-Limestone series, Law, Dalry. Lower part of lower-Limestone series, Crawfield, Kilbirnie. From shale above the Linn-Spout limestone at Stacklawhill, Stewarton. (J. Smith, J. Bennie.)

Order.—Calcispongiæ.

Family.—Pharetrones.

Genus.—Peronella, *Zittel.*

1878. Studien über fossile Spongien. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. ii, p. 120.

Syn.—Scyphia, Siphonia, Spongia, *Auct.*; Eudea (in part), Hippalimus (in part), *D'Orbigny;* Siphonocœlia (in part), Polycœlia (in part), Discœlia (in part), Stenocœlia, *Fromentel;* Pareudea (in part), *Etallon;* Dendrocœlia, *Laube;* Cœloconia, Dyoconia, Gymnorea, Pliocœlia, Siphonocœlia, Lœnocœlia, *Pomel;* Spongites, Dermispongia, Radicispongia, *Quenstedt.*

Sponges simple or branching from buds, the individual forms are cylindrical, with a simple tubular cloaca which extends to the base of the Sponge. The basal portion occasionally with a smooth or corrugated dermal layer, the upper portion of the Sponge usually without a special membrane over the fibres. The circulation appears to have been carried on through the irregular interspaces of the skeletal-fibres, and special canals are not indicated in the skeleton. The anastomosing fibres form an irregular meshwork; they consist of three- and four-rayed spicules, of large and moderate dimensions, which are disposed approximately in the axial centre of the fibre, and are surrounded by similar but smaller spicules. Uniaxial spicules may possibly be also present.

This genus is stated to make its first appearance in the Devonian formation, and Prof. v. Zittel has referred to it *Scyphia conoidea*, Goldfuss, and *Scyphia constricta*, Sandberger. The spicular structure of these forms has, however, not yet been recognised, and it is not until reaching Jurassic strata that we find examples of *Peronella* in which the spicular structure of the fibres has been preserved. In calcareous shales of Carboniferous age from the East of Scotland Mr. James Bennie has found detached spicules, which in form, size, and mineral structure, correspond very closely with spicules of *Peronella*, and I therefore refer them provisionally to this genus.

51. Peronella sparsa, *Hinde,* sp. nov. Pl. IX, figs. 4, 4 *a*—4 *e*.

Detached three- and four-rayed spicules, the rays may be either subequal or inequal in length, or with two equal rays and one shorter ray, so as to resemble the "sagittate spicules" of Haeckel. They are approximately equi-angular, and in the same horizontal plane. The fourth ray, when present, is at right angles to the other three rays. The rays are smooth and slightly tapering, they terminate obtusely. They vary from ·15 to ·33 mm. in length, and from ·025 to ·062 mm. in thickness.

These spicules occur in calcareous shales, associated with the fragmentary remains of other minute organisms. They are of carbonate of lime and dissolve entirely in dilute acid. They have a porcellanic-white aspect by reflected light, and become translucent in Canada balsam. Their surfaces are smooth and even, and their outlines are as well-defined as the minute perforated plates of Holothurians, present in the same beds. No canals are preserved. Very seldom are the spicules complete, one or more of the rays are usually fractured.

Since it has been definitely proved that Calcisponges are capable of preservation in the fossil state, and detached spicules are known to be present in Tertiary strata ('Quart. Journ. Geol. Soc.,' vol. xlii, 1886, p. 214), there is no reason why they should not occur in the older rocks, as well as other similarly minute and delicate calcareous organisms. I do not see any ground for supposing that these forms are replaced siliceous spicules, since siliceous spicules of similar dimensions very seldom occur detached, and when they are preserved their outlines are usually eroded and quite unlike the present forms.

Distribution.—Lower Carboniferous: Woodend, Cowdens, Fife, Scotland (J. Bennie).

BAD AND DOUBTFUL SPECIES.

The forms referred to below, from various geological horizons of the Palæozoic series of Britain, have been placed by their authors or subsequent writers in the group of Sponges. I have given in each case the reason which has induced me to exclude them from this category, based, as far as possible, on an examination of the type-specimens which have been described. In some instances it has been possible to determine the true systematic position of these fossils, whilst the characters of others are too obscure to allow of any identification, and they must be at present regarded as *incertæ sedis.* I have not thought it necessary to refer

to the different British species of *Stromatopora*, formerly regarded as Sponges, since the Monograph on these fossils by Prof. Dr. H. A. Nicholson, F.L.S., now in course of publication, shows clearly their true relationship to the Hydrozoa. The species enumerated below are placed in alphabetical order.

52. Acanthospongia Siluriensis, *M'Coy*.

1862. A Synopsis of the Silurian Fossils of Ireland, p. 67.

The typical form is described as a "lengthened oval mass, about two inches long and three quarters of an inch wide, of crowded spicula varying in length from two lines to more than half an inch. The spicula resemble the letter X in shape, four of the rays being always very distinct and disposed in that form, but there also seems to have been certainly one similar ray extending upwards and another downwards from the centre, considering the other four to be horizontal. The rays are round, tapering, pointed, smooth, and apparently hollow. They remind us much of *Xanthidium* and those allied forms, but have obviously a stronger affinity with the group in which I have placed them, although I do not think I have seen even among any of the foreign Sponges such strong, star-like spicula."

No figure accompanies the description, and from this alone it is impossible to form an idea either of the form of the spicules or of their arrangement in the Sponge. Unfortunately, the type-specimen, which was in the collection of the late Sir R. Griffith, cannot now be found. It does not appear to have reached the Natural-History Museum in Dublin, in which the greater part of Sir R. Griffith's collection is now preserved, and nothing is known of it in the collection of the Geological Survey of Ireland. No other specimen corresponding to M'Coy's description has been discovered, and therefore the genus and species must lapse, at least for the present. There can hardly be a doubt that the original was a genuine Sponge, but whether it resembled *Protospongia* or the genus which I have named *Phormosella* cannot be determined. The type-specimen was from sandstone at Cong, near Galway, Ireland.

53. Astylospongia sp. (grata, *Salter* MS.)

1873. Cat. Cambrian and Silur. Foss. Cambridge, p. 40.

The original specimen, now in the Woodwardian Museum at Cambridge, is stated to be one of the lobed Sponges, but in reality it is only a cast, exhibiting ten ridges radiating from a common raised centre. Its character is doubtful; it may be the impression of the summit vault of a crinoid.

The figure given is a very imperfect representation of the original, which is said to be from Coniston.

54. Bothroconis plana, *King.*

1850. Mon. Permian Foss., Pal. Soc., vol. iv, p. 13, pl. ii, fig. 6.

The original specimens, now in the Museum of Queen's College, Galway, consist of shallow, circular depressions on the weathered surfaces of shelly limestone. In some instances the pits are close together, whilst in others there are considerable interspaces between them. Their origin is problematical; they may be due to mere weather-erosion since the limestone was exposed. They are certainly not Sponges.

The types are from Magnesian Limestone (Permian), Tunstall Hill, Durham.

55. Cnemidium tenue, *Lonsdale.*

1839. Murchison's Silurian System, p. 694, pl. xvi bis, figs. 11, 11 *a*, 11 *b*.

The original specimen, shown on the weathered surface of a slab of Wenlock Limestone, now in the Museum of the Geological Society of London, appears to be either a small coral or a polyzoon. It is from Dudley.

56. Coscinopora placenta ? *Lonsdale* (non *Goldfuss*).

1840. Transactions Geological Soc., ser. 2, vol. v, pl. lviii, figs. 5 *a*—5 *d*.

The original belongs to the Stromatoporoid group, and is the form known subsequently under the name of *Caunopora placenta.* It occurs in the Devonian Limestone of Plymouth and Torquay.

57. Entobia antiqua, *Portlock.*

1843. Report on the Geology of Londonderry, &c., p. 360, pl. xxi, figs. 5 *a*, 5 *b*.

Judging from examples of this species now in the Museum of the Geological Survey, Jermyn Street, which correspond closely with Portlock's descriptions and

figures, and come from the same locality as the type-specimen, it is very distinctly a polyzoon belonging either to *Hippothoa* or *Stomatopora*. H. M. Fischer has also stated that it belongs to the Bryozoa ("Recherches sur les Éponges perforantes Fossiles," 'Nouv. Archiv. du Mus d'Histoire Naturelle,' 1868, p. 133). In Morris's 'Catalogue,' 1854, p. 27, it is placed with the Amorphozoa under the genus *Cliona*.

The original specimens are from strata of Caradoc age, at Desertcraight, Tyrone.

58. Favospongia Ruthveni, *Salter* (MS.).

1855. Brit. Pal. Fossils, pl. i D, figs. 9, 9 *a*.

The examples of this species are mere structureless casts of ovoid bodies, their surfaces are covered with indistinct, circular, or irregular depressions. Their true character is problematical; there is no evidence to connect them with Sponges.

The specimens thus named are from Upper-Ludlow strata at Benson Knot, near Kendal; they are now in the Museum of the Geological Society of London, and in the Jermyn Street Museum.

59. Ischadites micropora, *Salter*.

1873. Cat. Cambrian and Silur. Foss. Cambridge, p. 40.

The specimen thus named is a fragmentary cast of some organism exhibiting rows of puncta on the surface of compressed shale. It does not show any resemblance to *Ischadites* or allied forms. The original, now in the Woodwardian Museum at Cambridge, comes from Middle-Bala strata at Blaen-y-cwm, North Wales.

60. Mammillopora mammillaris, *King*.

1850. Mon. Permian Foss., Pal. Soc., vol. iv, p. 12, pl. ii, figs. 3, 4.

The type is a small rounded mass with mammillary elevations. The surface is entirely covered with very minute polygonal perforations, similar to those of the doubtful organism *Solenopora compacta*, Billings sp. (see 'Geol. Mag.,' dec. iii, vol. ii, p. 529). No other structure is shown. This is certainly not a Sponge.

From shelly limestone (Permian), Humbleton Hill. The type is in the Museum of Queen's College, Galway.

61. Palæacis cuneata, *Meek and Worthen* sp.

1860. Proc. Acad. Nat. Sciences Philadelphia, p. 448.

Examples of this species have been discovered in the Carboniferous Limestone near Henbury, Bristol ('Geol. Mag.,' 1876, dec. ii, vol. iii, p. 267). The original form was referred to the *Petrospongiæ*; in Bigsby's 'Thesaurus Devonico-Carboniferus,' p. 201, it is placed with the Amorphozoa under the name of *Sphenopoterium cuneatum*. The nature of the fossil is doubtful; it appears to me to be rather related to corals than to Sponges.

62. Protospongia diffusa, *Salter*.

1873. Cat. Cambrian and Silur. Foss. Cambridge, p. 3.

This species is based on a few scattered, rod-like, rusty markings on the surface of a fragment of black shale of Menevian age from St. David's, South Wales. It is doubtful whether the markings represent Sponge-spicules. The original specimen is in the Woodwardian Museum at Cambridge.

63. Protospongia ? flabella, *Hicks*.
64. — ? major, *Hicks*.

1871. Quart. Journ. Geol. Soc., vol. xxvii, p. 401, pl. xvi, figs. 14—19.

The typical examples of these species, now in the Woodwardian Museum at Cambridge, consist of slightly raised, sub-parallel, straight or curved lines, which are sometimes crossed by other lines at varying angles. No structure whatever is preserved. The character of these markings is doubtful, and they are too indefinite to be regarded as portions of Sponge-structure. They occur in the Harlech Grits, near St. David's, South Wales.

65. Protospongia Ludense[is], *Holl*.
66. — maculæformis, *Holl*.

1872. Geological Magazine, vol. ix, p. 350.

These two species were described by the late Dr. Holl in a foot-note to his paper on "Fossil Sponges," but the specimens were not figured. They were from

the Lower-Ludlow strata of Leintwardine, and the originals were stated to be in the Ludlow Museum, but they cannot now be found. I had been in correspondence with Dr. Holl shortly before his death respecting these types, and, acting on a suggestion made by him, I examined, by the kind permission of Prof. Boyd Dawkins, F.R.S., the Lightbody collection, now in the Museum of Owens College, Manchester, but without meeting with them. Their loss is the more to be regretted since no other specimens corresponding with Dr. Holl's descriptions have been discovered, and his species will therefore lapse. It seems to me probable that *Protospongia Ludensis* may have belonged to the genus *Dictyophyton*, and *P. maculæformis* to *Phormosella*.

67. PULVILLUS THOMSONII, *Carter*.

1878. Annals and Mag. Nat. Hist., ser. 5, vol. i, p. 137, pl. x, figs. 1—6.

I am indebted to Mr. James Thomson, F.G.S., for the opportunity of examining the type forms of this new genus and species. The specimens are bi-convex or plano-convex discs with occasionally a depression on one or both surfaces. They are composed of rounded or amorphous grains of calcite, from 1 to 3 mm. each in diameter, closely aggregated together, so that in a section but little more than the partition line between the individual grains is visible. In some cases the grains are separated by rock matrix from each other. There are no traces of Sponge-fibres of any kind nor of canals. The constituent grains of calcite in part exhibit an acicular or fibrous crystalline structure, which is regarded by Mr. Carter as indicating acerate Sponge-spicules (*loc. cit.*, pl. x, fig. 4).

Further, the objects represented as "broken ends of the spicules projecting from the surface of the large excavation" in the type-specimen appear to me to be punctures in a fragment of the shell of some Brachiopod (*l. c.*, pl. x, fig. 6). The acerate spicule, figured as the staple form of a perfect spicule (*l. c.*, pl. x, fig. 5), is derived from the sandy material of the rock matrix, and there is no evidence beyond its position that it had any relation to the supposed Sponge.

These bodies in my opinion are merely nodules of inorganic origin. They are from Carboniferous Limestones at Arbigland, near Dumfries.

68. SCYPHIA TUBERCULATA, *King*.

1850. Mon. Permian Foss., Pal. Soc., vol. iv, p. 12, pl. ii, figs. 1, 2.

The type-specimen, now in the Museum of Queen's College, Galway, is a fragment of a cylindrical body, with a hollow axial tube and lateral tubes partly

connecting with it. No perforations are shown in the surface tubercles. The interior structures are entirely obliterated, and the nature of the organism is altogether doubtful.

From shelly limestone (Permian) at Humbleton Hill and Dalton-le-Dale, Durham.

69. Scyphia turbinata, *Lonsdale* (non *Goldfuss*).

1840. Trans. Geol. Soc., ser. 2, vol. v, pl. lviii, fig. 9.

I have not seen the type-specimen, the only description states : " Two pyritous specimens, embedded in slate, from the vicinity of Plymouth." Judging from the figure their characters are highly problematical. They are not likely to belong to Goldfuss's species from the Upper Jura of Streitberg, in which they have been placed by Lonsdale.

70. Sphærospongia hospitalis, *Salter*.

1873. Cat. Cambrian and Silur. Foss. Cambridge, p. 40.

This species is not congeneric with *Sphærospongia tessellata*, Phill., and probably it is related to the genus *Pasceolus*, Bill., in any event it is not a Sponge. The original is from the Middle Bala Group at Onny River, Shropshire.

71. Steganodictyum Carteri, *M'Coy*.
72. Steganodictyum cornubicum, *M'Coy*.

1855. Brit. Pal. Foss., pl. ii a, figs. 1—4.

These forms, regarded by the author as Sponges, were pointed out by Salter to be the cephalic plates of a Pteraspidian fish. This conclusion was fully confirmed by Prof. Ray Lankester, who has referred them to *Cephalaspis* and *Scaphaspis* respectively ('Quart. Journ. Geol. Soc.,' vol. xxiv, p. 546). They are found in hard slates of Devonian age, at Polperro, Cornwall.

73. Tragos Binneyi, *King.*

1850. Mon. Permian Foss., Pal. Soc., vol. iv, p. 13, pl. ii, fig. 6.

The type-specimen, now in the Museum of Queen's College, Galway, shows no traces of organic structure, and appears to me to be of inorganic origin. It comes from Bradford, near Manchester.

74. Tragos semicirculare [is], *M'Coy.*

1844. Synop. Carb. Foss. Ireland, p. 196, pl. xxvii, fig. 8.

The typical, figured example of this species, now in the Museum of Science and Art, Dublin, is a fish tooth, weathered out on the surface of a slab of limestone. It comes from the Carboniferous (Upper Limestone series) of Manor Hamilton.

75. Tragos Tunstallensis, *King.*

1850. Mon. Permian Foss., Pal. Soc., vol. iv, p. 13, pl. ii, fig. 5.

The type forms included in this species show no traces of organic structure, and appear to be only small nodular secretions, in one instance enclosing a small *Murchisonia*. I am unable to distinguish the fibrous texture described by the author. The specimens, labelled apparently in Professor King's own handwriting, are now in the Museum of Queen's College, Galway. They are from Magnesian Limestone (Permian), Tunstall Hill, Durham.

76. Verticillipora ? abnormis, *Lonsdale.*

1839. Silurian System, p. 693, pl. xvi bis, figs. 10 *a*—10 *d*.

The type-specimen, now in the Museum of the Geological Society of London, is a small coral or polyzoön. Though the author placed it in a genus of reputed Sponges, he yet regarded it as a coral. It is relegated to the genus *Ceriopora*, Goldfuss, in 'Morris's Catalogue,' 2nd ed. p. 120; but in 'Siluria,' ed. 1867, it still retains the original name and is placed under the Amorphozoa (p. 509). The specimen is from Ludlow strata at Pyrton, Gloucestershire.

77. Verticillipora dubia, *M'Coy.*

1844. Synop. Carb. Foss. Ireland, p. 194, pl. xxvii, fig. 12.

This species is founded on a specimen of incrusting coral or polyzoa. It is placed in the genus *Ceriopora*, Goldfuss, in 'Morris's Cat. Brit. Foss.,' 2nd ed., p. 120.

78. Verticillopora palmata, *Salter.*

1873. Cat. Cambrian and Silur. Foss. Cambridge, p. 100.

The original specimen, now in the Woodwardian Museum at Cambridge, is palmate, with vertical bifurcating branches. The outer surface is smooth. The structure is but very imperfectly preserved, but, judging from thin microscopic sections, it appears to be either a coral or a form of the Stromatoporoidea.

The specimen is from Wenlock strata at Dudley.

79. Vioa prisca, *M'Coy.*

1855. Brit. Pal. Fossils, p. 260, pl. 1 b, figs. 1, 1 *a*.

This species is founded on straight or slightly-curved tubular borings in the shell of a *Pterinea*, which have no definite resemblance to the undoubted perforation of boring Sponges. Salter states that they are due to an annelid ('Cat. Cambrian and Silur. Foss. Cambridge,' p. 85); and their Sponge origin has likewise been called in question by M. P. Fischer ("Recherches sur les Éponges perforantes fossiles," 'Nouv. Archiv. du Mus. d'Histoire Naturelle,' 1868, p. 134).

The form is placed under the genus *Cliona* in 'Morris's Catalogue,' 1854, p. 27. The figured type, from the Upper Silurian of Malvern, is in the Woodwardian Museum, Cambridge.

TABLE I.—*List of British Palæozoic Sponges, their Stratigraphical Distribution, and the page and plate in which they are described and figured.*

Name of Genus and Species.	Reference to Page and Plate.	Cambrian.	Ordovician.	Silurian.	Devonian.	Carboniferous.	Permian.
MONACTINELLIDÆ.	PAGE						
Atractosella siluriensis, *Hinde*	123, Pl. I, figs. 6, *a—d*	...	...	×			
Reniera Carteri, *Hinde*	142, Pl. IV, figs. 5, *a—f*	...	...	...	...	×	
— scitula, *Hinde*	142, Pl. IV, fig. 4	...	...	...	...	×	
— clavata, *Hinde*	143, Pl. IX, figs. 5, *a*, *b*	...	...	...	...	×	
— virga, *Hinde*	143, Pl. IX, figs. 6, *a*, *b*	...	...	...	...	×	
— gracilis, *Hinde*	144, Pl. IX, figs. 7, *a*, *b*	...	...	...	...	×	
— Zitteli, *Počta*	144, Pl. IX, figs. 8, *a—c*	...	...	...	...	×	
— bacillum, *Hinde*	144, Pl. IX, fig. 9	...	...	...	...	×	
Axinella vetusta, *Hinde*	145, Pl. IV, fig. 6	...	...	...	...	×	
— paxillus, *Hinde*	145, Pl. IX, fig. 10	...	...	...	...	×	
Haplistion Armstrongi, *Young*	147, Pl. V, figs. 1, *a*, *b*	...	...	...	...	×	
— vermiculatum, *Carter* sp.	148, Pl. V, figs. 2, *a*	...	...	...	...	×	
TETRACTINELLIDÆ.							
Geodites antiquus, *Hinde*	150, Pl. V, figs. 3, *a—d*	...	...	...	...	×	
— deformis, *Hinde*	150, Pl. V, figs. 4, *a—g*	...	...	...	...	×	
— hastatus, *Hinde*	151, Pl. IX, figs. 11, *a*, *b*	...	...	...	...	×	
— cornutus, *Hinde*	151, Pl. IX, figs. 12, *a—e*	...	...	...	...	×	
— simplex, *Hinde*	152, Pl. IV, fig. 3	...	...	...	...	×	
Pachastrella vetusta, *Hinde*	153, Pl. V, figs. 5, *a—c*	...	...	...	...	×	
— humilis, *Hinde*	154, Pl. IV, fig. 7	...	...	...	...	×	
LITHISTIDÆ.							
Astylospongia inciso-lobata, *F. Roemer*	114, Pl. II, figs. 5, *a*	...	×				
Hindia fibrosa, *F. Roemer* sp.	116, Pl. IX, figs. 3, *a—e*	...	×				
— pumila, *Hinde*	157, Pl. V, figs. 8, *a—f*	...	...	...	...	×	
Cnemidiastrum priscum, *Hinde*	155, Pl. V, figs. 6, *a—f*	...	...	...	...	×	
Doryderma Dalryense, *Hinde*	156, Pl. V, figs. 7, *a—c*	...	...	...	...	×	
HEXACTINELLIDÆ.							
Protospongia fenestrata, *Salter*	106, Pl. I, figs. 1, 1, *a*	×					
— Hicksi, *Hinde*	107, Pl. I, figs. 2, 2, *a*	×					
Hyalostelia fasciculus, *M'Coy* sp.	110, Pl. I, figs. 3, *a*, *b*	×	×				
— gracilis, *Hinde*	129, Pl. I, figs. 5, *a—e*	...	...	×			
— Smithii, *Young & Young* sp.	118, 158, Pl. I, figs. 4, *a*; Pl. VI, figs. 1, *a—l*, 2, *a—k*	...	×	...	...	×	

Name of Genus and Species.	Reference to Page and Plate.	Cambrian.	Ordovician.	Silurian.	Devonian.	Carboniferous.	Permian.
HEXACTINELLIDÆ (*continued*).	PAGE						
Hyalostelia parallela, *M'Coy* sp.	161, Pl. VI, figs. 3, *a—g*	...	...	...	...	×	
Plectoderma scitulum, *Hinde*	124, Pl. III, figs. 1, *a*, *b*	...	...	×			
Phormosella ovata, *Hinde*	125, Pl. III, figs. 2, *a*, *b*	...	...	×			
Dictyophyton Danbyi, *M'Coy* sp.	128, Pl. II, figs. 4, *a—c*	...	...	×			
Holasterella conferta, *Carter*	164, Pl. VIII, figs. 2, *a—g*	...	...	...	...	×	
Spiractinella Wrightii, *Hinde*	165, Pl. VIII, figs. 1, *a—h*	...	...	...	...	×	
Acanthactinella Benniei, *Hinde*	167, Pl. VIII, figs. 4, *a—i*	...	...	...	...	×	
Amphispongia oblonga, *Salter*	131, Pl. III, figs. 3, *a—f*	...	...	×			
Ischadites Kœnigii, *Murch*	120, Pl. II, figs. 1, *a*, *b*	...	×	×			
— Lindstrœmi, *Hinde*	129, Pl. II, fig. 2, *a*	...	...	×			
Sphærospongia tessellata, *Phillips*	136, Pl. IV, figs. 2, *a—d*	...	...	...	×		
Receptaculites Neptuni, *Defrance*	139, Pl. II, fig. 3; Pl. IV, fig. 1	...	...	×	×		
OCTACTINELLIDÆ.							
Astræospongia patina, *F. Roemer*	134, Pl. I, figs. 7, *a—d*	...	...	×			
— Devoniensis, *Hinde*	140, Pl. IV, figs. 8, *a—c*	...	...	...	×		
HETERACTINELLIDÆ.							
Tholiasterella Youngi, *Hinde*	169, Pl. VII, figs. 2, *a—f*	...	...	...	...	×	
— gracilis, *Hinde*	170, Pl. VII, figs. 1, 1, *a—g*	...	...	...	...	×	
— compacta, *Hinde*	171, Pl. VII, figs. 3, 3, *a*	...	...	...	...	×	
— crassa, *Hinde*	171, Pl. VIII, fig. 5, *a*; Pl. IX, figs. 2, *a*, *b*	...	...	...	...	×	
Asteractinella expansa, *Hinde*	173, Pl. VIII, figs. 3, *a—h*	...	...	...	...	×	
— tumida, *Hinde*	174, Pl. IX, figs. 1, *a—g*	...	...	...	...	×	
CALCISPONGIÆ.							
Peronella sparsa, *Hinde*	176, Pl. IX, figs. 4, *a—e*	...	...	...	...	×	

TABLE II.—*List of Bad and Doubtful Species in Alphabetical Order.*

	PAGE	Cambrian.	Ordovician.	Silurian.	Devonian.	Carboniferous.	Permian.
Acanthospongia siluriensis, *Salter*	177	...	...	×			
Astylospongia grata, *Salter*, MS.	177	...	×				
Bothroconis plana, *King*	178	...	...	...		...	×
Cnemidium tenue, *Lonsdale*	178	...	...	×			
Coscinopora placenta, *Lonsdale*	178	...	...	...	×		
Entobia (Cliona) antiqua, *Portlock*	178	...	×				
Favospongia Ruthveni, *Salter*, MS.	179	...	...	×			
Ischadites micropora, *Salter*	179	...	×				
Mammillopora mammillaris, *King*	179	...	...	...	...	...	×
Palæacis cuneata, *Meek and Worthen* sp.	180	...	...	...	...	×	
Protospongia diffusa, *Salter*	180	×					
— ? flabella, *Hicks*	180	×					
— ? major, *Hicks*	180	×					
— ludensis, *Holl.*	180	...	...	×			
— maculæformis, *Holl.*	180	...	...	×			
Pulvillus Thomsonii, *Carter*	181	...	...	...	...	×	
Scyphia tuberculata, *King*	181	...	...	...	...	...	×
— turbinata, *Lonsdale*	182	...	...	...	×		
Sphærospongia hospitalis, *Salter*	182	...	×				
Steganodictyum Carteri, *M'Coy*	182	...	...	...	×		
— cornubicum, *M'Coy*	182	...	...	...	×		
Tragos Binneyi, *King*	183	...	...	...	...	...	×
— semicirculare [is], *M'Coy*	183	...	...	...	...	×	
— Tunstallensis, *King*	183	...	...	...	...	...	×
Verticillopora abnormis, *Lonsdale*	183	...	...	×			
— dubia, *M'Coy*	184	...	...	...	...	×	
— palmata, *Salter*	184	...	...	×			
Vioa (Cliona) prisca, *M'Coy*	184	...	...	×			

It will be seen from the foregoing list that in all fifty species of fossil Sponges have been enumerated from the Palæozoic strata of the British area. The numbers of species of each of the principal groups of Sponges are as follows :—Monactinellidæ twelve, Tetractinellidæ seven, Lithistidæ five, Hexactinellidæ seventeen, Octactinellidæ two, Heteractinellidæ six, and Calcispongiæ one species.

From the Cambrian strata there are at present three species known, all of which are Hexactinellids : from the Ordovician five species, two of which are Lithistids and three Hexactinellids ; from the Silurian ten species, of which one belongs to the Monactinellidæ, eight are Hexactinellids, and one an Octactinellid ; from the Carboniferous thirty-three species, of which eleven are Monactinellids,

seven Tetractinellids, three Lithistids, five Hexactinellids, six Heteractinellids, and one species of Calcisponge. No Sponge has been discovered in Permian strata.

Of the total number of species, forty-three are limited to a single system; one species passes from the Cambrian to the Ordovician, two from the Ordovician to the Silurian, one from the Ordovician to the Carboniferous, and one from the Silurian to the Devonian. Two of the Carboniferous species are, so far as can be determined from the spicules, identical with forms from the Lower Cretaceous of the South of England.

Only ten out of the fifty species are known to occur beyond the British area. These forms are present at corresponding geological horizons in Scandinavia, Germany, Belgium, Russia, and North America.

Of the species hitherto included as Palæozoic Sponges, twenty-eight are removed as bad or doubtful forms.

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OF THE

BRITISH FOSSIL SPONGES.

BY

GEORGE JENNINGS HINDE, Ph.D., F.G.S.

PART III.

SPONGES OF JURASSIC STRATA.

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PART III.

SPONGES OF JURASSIC STRATA.

INTRODUCTION.

In the series of rocks between the Yoredale beds of the Carboniferous Limestone and the Lower Lias there is an absence of fossil sponges in the British area, and throughout this interval (represented by the Millstone Grit, the Coal-Measures, the Magnesian Limestones and Red Marls of the Permian period, and the sandstones, marls, and shales of the Rhætic deposits) we can only suppose either that the conditions under which the strata were formed were unsuitable to sponge-life, or, what is perhaps more probable, that subsequent fossilisation has removed all traces of their existence. However this may be, it is certain that not until reaching the horizon of the Lower Lias do we find sponge remains in any abundance, and even here these organisms are only represented by detached spicules. In some beds of the Lower Liassic Limestones of Glamorganshire, near Brocastle and the neighbourhood, sponge-remains form, as pointed out by the late Mr. Charles Moore,[1] an important constituent of the rock. The beds are filled with spicules, in form resembling those of the still existing genus *Pachastrella*, Os. Schmidt, but their original silica has been removed and they now consist of carbonate of lime. Similarly some beds of limestone on the same geological horizon, near Shepton Mallet, Somersetshire, are crowded with detached spicules of siliceous sponges now replaced by calcite (Pl. XIII, fig. 4). At Harptree, in the same neighbourhood on the Mendip plateau, there are beds of chert of some considerable thickness belonging to nearly the same horizon as the limestones, which may very probably have been derived from the organic silica of sponges, although, with one or two exceptions, spicules are not recognisable in them.

[1] 'Quart. Journ. Geol. Soc.,' vol. xxiii, 1867, p. 538.

In the Middle Lias the only siliceous sponge yet known is a solitary specimen of the Lithistid genus *Platychonia* (Pl. XII, figs. 4, 4 *a*) discovered by the Rev. P. B. Brodie in the Marlstone at Ilminster. In some decayed rusty beds of the sand rock at King's Sutton, in Northamptonshire, Mr. E. A. Walford found the minute specimens of *Leucandra Walfordi*, Hinde (Pl. XIX, figs. 8—8 *c*), the earliest known fossil Calcisponges in this country, with the exception of some detached spicules occurring in Carboniferous strata, and further distinguished as the sole fossil representatives of the family of Leucones, very numerous in existing seas.

From the Upper Lias no sponges are as yet known in our area, but in the Inferior Oolite they occur in great abundance, and they form an important, though hitherto scarcely recognised, element of the fauna of this series.

In the lower division of the Inferior Oolite in the Cotteswold area, included in the zone of *Ammonites Murchisonæ*, an interesting group, inclusively of Calcisponges, has been brought to light through the researches of Mr. R. F. Tomes, Mr. F. Longe, and others. They mostly belong to *Peronidella tenuis*, Hinde; *Corynella punctata*, Hinde; *Lymnorella mamillosa*, Lamx.; *L. inclusa*, Hinde; *L. ramosa*, Hinde; and *Blastinia costata*, Goldfuss, and they occur more particularly in the Pea-grit series and in the Oolite-Marl of Crickley Hill, Cleve Hill, and Ravensgate Hill, near Cheltenham, and at Birdlip Hill, near Gloucester. Lately, Mr. E. Wethered has pointed out the occurrence of several of these species in a definite sponge-bed in the Pea-grit series, exposed in a railway cutting at Andoversford, near Cheltenham ('Quart. Journ. Geol. Soc.,' vol. xlvii, 1891, p. 553). In this lower division of the Inferior Oolite, sponges belonging to the genus *Lymnorella*, Lamx., are by far the most numerous; they frequently occur in nodular masses, partly incrusted by Polyzoa.

In the higher division of the Inferior Oolite, belonging to the zone of *Ammonites Parkinsoni*, British Jurassic sponges reach their greatest development. They are best shown in the grey limestone strata which cap the cliff at Burton Bradstock, near Bridport, Dorsetshire. Large masses of this limestone have in places fallen to the beach and have become weathered, and their upper surfaces show that the rock is mainly composed of masses of sponges growing attached to each other, apparently still in their natural position. The greater number are evidently siliceous sponges, but though they retain their original forms fairly well, their canal structures are largely obliterated, and the silica of their spicular skeletons has been entirely replaced by carbonate of lime, and thus they offer great difficulty in determining their character and relationships. The majority of the siliceous sponges in these beds are Hexactinellids, belonging to the genera, *Tremadictyon*, Zittel; *Calathiscus*, Sollas; *Craticularia*, Zittel; *Verrucocœlia*, Etallon; and *Stauroderma*, Zittel, but there are also several species of the

Lithistid genera *Platychonia*, Zittel, and *Leiodorella*, Zittel, as well as a few Calcisponges belonging to the genus *Peronidella*, Zittel.

At Shipton Gorge, not far from Burton Bradstock, in a quarry of the Inferior Oolite Limestone, on the same *Parkinsoni*-zone, Mr. E. A. Walford[1] discovered a thin sponge-bed containing an extraordinary number of small sponges associated with numerous species of Polyzoa. In contrast to the sponge-bed at the Burton Bradstock Cliff, which mostly consists of siliceous sponges, the Shipton Gorge bed is nearly entirely of Calcisponges belonging to the genera *Peronidella*, Zittel; *Holcospongia*, Hinde; *Lymnorella*, Lamx.; *Oculospongia*, Fromentel; and *Eudea*, Lamx.; and the specimens are mostly of small dimensions. Only a few broken-up fragments of siliceous sponges are present in the same bed with the Calcisponges, and in these the siliceous structure has been entirely replaced by calcite, whilst the Calcisponges are hardly at all altered in their mineral composition, thus showing that, under similar conditions, siliceous sponges have much less capacity for resisting the destructive effects of fossilisation than Calcisponges. In comparison with the difference of habitat in existing Hexactinellids and Calcisponges, it is interesting to note the joint existence of members of these groups in the same beds of the Inferior Oolite at this place. In some cases small Calcisponges still remain attached to the surface of Hexactinellids on which they have grown; whilst in others the basal dermal surfaces of Calcisponges retain the imprint of the cruciform, dermal spicules of sponges belonging to the genus *Stauroderma*, Zittel, which formerly served them as a basis of growth.

Beyond these two Dorsetshire localities there are but few others in the south-west of England which have yielded sponges in the upper beds of the Inferior Oolite. At Dundry Hill, near Bristol, the rare Lithistid, *Melonella ovata*, Sollas, sp., has been met with in the zone of *Am. Humphresianus*, and at Bradford Abbas, Dorset, a few specimens of *Peronidella* and *Holcospongia*.

Passing upwards to the Great Oolite series it is significant that only Calcisponges have as yet been found in these rocks in the British area. Members of this group are, however, by no means rare, and a very fine collection from the Great Oolite at Hampton Cliffs, near Bath, made by the late Mr. W. Walton, and presented by him to the Woodwardian Museum at Cambridge, has mainly served for the descriptions and figures given below. They are comprised in the following genera: *Peronidella*, *Eusiphonella*, *Corynella*, *Holcospongia*, *Lymnorella*, *Elasmostoma*, and *Diaplectia*. In the Forest Marble at Winsley, near Bath, in the Bradford Clay at Bradford-on-Avon, Wiltshire, and in the Cornbrash at Langton Herring, near Weymouth, a few Calcisponges also occur; those from the last-named places retain their spicular structure very perfectly.

Some beds in the well-boring at Richmond, Surrey, at 1205 feet beneath the

[1] 'Quart. Journ. Geol. Soc.,' vol. xlv, 1889, p. 561.

surface, which have been referred to the horizon of the Great Oolite, were found also to contain some small Calcisponges; these, however, appear to be more nearly related to the species from the Inferior Oolite at Shipton Gorge than to those from the Great Oolite near Bath, and it may be noticed that Mr. E. A. Walford has also found that several species of Polyzoa met with in the Richmond material associated with the small sponges, likewise occur in the Inferior Oolite at Shipton Gorge.

From the Kelloways Rock and the Oxford Clay proper, no sponges have been obtained, but in the different divisions of the Corallian series in Yorkshire, included in the zones of *Ammonites perarmatus* and *Am. plicatilis*, they again make their appearance, and sometimes in sufficient numbers to affect the character of the rock. Throughout the entire series only one species of siliceous sponge has been recorded, and this is the peculiar *Rhaxella perforata*, Hinde (Pl. XIII, figs. 7—7 *f*), whose skeleton is made up of microscopic globate spicules. Examples of it occur in the Lower Calcareous Grit of Scarborough, and in the higher horizon of the Coral Rag at Settrington, Yorkshire. Though definite specimens of this sponge are rare, the detached microscopic globates, either of this or of other allied species, occur so abundantly as to form the larger part of considerable beds of rock and give rise to layers of chert of some thickness. Mr. W. H. Hudleston states that the lower part of the Lower Calcareous Grit at Scarborough consists of a poriferous mass of siliceous material not unlike a fine-grained sponge cake ('Proc. Geol. Ass.,' vol. iv, 1876, p. 384); the porous character being due to the solution of the minute, globate, sponge spicules which have left pinhole-like cavities in the rock.[1] In other instances the globates are preserved in a siliceous or calcareous matrix, and from this latter they can be obtained quite free by means of acid. The section at Scarborough Castle shows, according to Mr. Hudleston, a bed of chert, 3 feet 4 inches in thickness, and beneath this rough grits, 30 feet in thickness, belonging to the Lower Calcareous Grit, which are largely composed of these globate spicules. Hand-specimens of the grit from Falgrave Moor and other places near Scarborough, sent to me by Mr. Fox-Strangways, and from Filey, obtained by Mr. S. Chadwick, are mainly composed of these spicules. In the Coral Rag of North Grimston, Yorkshire, the same globates occur in great numbers, and Mr. Hudleston attributes the prevalent siliceous character of the Rag in this locality to the silica derived from these sponge remains. Similar detached spicules, unconnected with any definite form of sponge, have been described by Mr. J. F. Blake in the Coral Rag at Sturminster Newton, Dorsetshire, and at Hilmarton, near Colne, Wiltshire.

The Lower Calcareous Grit at Filey, and at Scarborough and the neighbour-

[1] An excellent description of the peculiar characters of this rock is also given by Mr. C. Fox-Strangways, 'Mem. Geol. Surv., Jurassic Rocks of Britain,' vol. i, Yorkshire, pp. 304 *et seq.*

hood, also contains a good many Calcisponges, principally belonging to *Holcospongia floriceps*, Phillips, sp., which frequently grows in colonies of considerable size.

This same species, together with *Holcospongia polita*, Hinde, and *Blastinia aspera*, Hinde, is fairly abundant in the Lower Limestone belonging to the upper part of the *Am. perarmatus*-zone at Suffield and Hackness, near Scarborough. Calcisponges are also fairly common in the white limestones of the higher horizons of the Corallian Oolite and Coral Rag at Langton Wold, near Malton, and at Settrington; they belong to *Corynella Langtonensis*, Hinde; *C. Chadwicki*, Hinde; and *Holcospongia glomerata*, Quenst., sp.

Though Calcisponges are abundant in the Corallian series of Yorkshire, they are rare in the corresponding beds in the South-west of England; only a few examples of *Holcospongia* are as yet known from the Coral Rag of Lyneham, Wiltshire.

From the Portland beds no entire fossil sponges are as yet known, but in some of the chert nodules in the limestones on the Isle of Portland and at Upway, near Weymouth, there are numerous detached spicules of *Pachastrella antiqua*, Moore, sp., and of *Geodites*, sp., thus showing that, in part at least, the chert of these rocks is derived from sponge remains.

In the fresh-water beds of the Purbeck series at Stare Cove, Dorsetshire, cherty nodules are present, and some of these were found by Mr. J. Young to be composed of minute acerate spicules which are referred to *Spongilla Purbeckensis*, Young.

From the different divisions of the British Jurassic series, fifty-six species of fossil sponges are described in the following pages; of these, twenty species are Siliceous sponges and thirty-six Calcisponges. The following list shows the numbers in each group:

	Siliceous Sponges.	Calcisponges.
Lias . . .	2 .	1
Inferior Oolite . .	15 .	19
Great Oolite . . .	— .	14
Corallian . . .	1 .	7
Portland Beds . .	2 .	—
Purbeck Beds . .	1 .	—

Very few species pass from one division to another; of the siliceous sponges, only one, *Pachastrella antiqua*, Moore, sp., which occurs at the bottom of the Lias and again in the Portland beds. Four species of Calcisponges are present both in the Inferior Oolite and in the Great Oolite, and one species is common to the Great Oolite and the Corallian rocks. Hexactinellid sponges have only been found in the Inferior Oolite, and here they are accompanied by Lithistids and Calcisponges.

Of the fifty-six species recognised in the British area, only nine occur in the

corresponding Jurassic strata of France, Germany, and Switzerland; but there are many other species closely allied to Continental forms. It is a noticeable fact that, as first mentioned by Prof. Sollas,[1] some of the species and nearly all the genera of Hexactinellid and Lithistid sponges present in the Inferior Oolite of Dorsetshire are similar to those which in Würtemberg and in the Swiss Jura appear in the distinctly higher horizon of the Upper, or White, Jura. Thus the genera *Tremadictyon*, *Verrucocœlia*, *Stauroderma*, *Platychonia*, and *Melonella*, together with *Craticularia clathrata*, Goldf., sp., and *C. foliata*, Quenstedt, sp., all recur in the Upper Jura in Germany. The Sponge-bed in the Inferior Oolite at Burton Bradstock, may well be compared in the number, variety, and mineral condition of its siliceous sponges with one of the zones of Spongiten-Kalk in the White Jura of Würtemberg. There is no sponge-bed in the corresponding middle Dogger in Germany to compare with that in our Inferior Oolite; and, on the other hand, there are no beds of Siliceous Hexactinellid sponges in our Corallian and Portland strata at all analogous to the sponge-zones in the Upper Jura of Germany.

The great abundance of Calcisponges forms the characteristic feature of the sponge fauna of our Jurassic rocks. In the Inferior Oolite the number of species exceeds that of the siliceous forms; in the Great Oolite there are fourteen species and no representative of siliceous sponges, and in the Corallian series there are seven species, as compared with a single species of siliceous sponges. Throughout the different divisions, the Calcisponges are fairly well preserved, their mineral structures are rarely altered, and in most of them the spicular character of the fibres can be recognised in thin sections, whilst in some the smallest spicules have been preserved intact.

In conclusion, I wish to acknowledge the generous assistance which I have received in the preparation of this part of the monograph. Mr. R. F. Tomes, of Evesham, Rev. G. F. Whidborne, Mr. F. Longe, of Cheltenham, and Mr. E. Wethered have supplied me with numerous specimens from the Pea-grit and the other beds of the Inferior Oolite. To my friend Mr. E. A. Walford, of Banbury, I am specially indebted for the beautiful little Calcisponges from the Middle Lias, and for the extraordinary variety and abundance of sponges which he obtained from the Inferior Oolite beds at Shipton Gorge. For the Yorkshire examples of Corallian sponges I am further indebted to the untiring energy and zeal of Mr. S. Chadwick, who has repeatedly sent me specimens and obtained for me the required information as to their occurrence. I also wish very heartily to thank Prof. T. McKenny Hughes for the opportunity of studying the unrivalled collection of Great Oolite Calcisponges in the Woodwardian Museum at Cambridge, and also to Mr. H. M. Platnauer my best thanks are due for the loan of valuable specimens from the Museum at York.

[1] 'Quart. Journ. Geol. Soc.,' vol. xxxix, 1883, p. 551.

DESCRIPTION OF GENERA AND SPECIES.

JURASSIC SPONGES.

Sub-order.—HEXACTINELLIDÆ.

Group.—DICTYONINA.

Genus.—TREMADICTYON, *Zittel.*

1877. Studien über fossile Spongien, I. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. i, p. 46.

Syn.—Scyphia, *Auct.* (in part); Cribrospongia, *d'Orbigny* (in part); Cribroscyphia, *Fromentel* (in part); Cribrocœlia, *Etallon* (in part); Retispongia, *Quenstedt* (in part).

Sponges cup-, platter-shaped, or cylindrical, with wide central cavity. On both the outer and inner surfaces of the wall there are tolerably large oval or rhomboidal ostia, disposed in rows alternately. Radial canals blind. The lattice-like skeleton of the wall and basal portion of the sponge consist of large irregular meshes, resulting from the frequent thickening and expansion of the spicular rays. The spicular nodes are compact. When well-preserved both surfaces of the wall are covered by an extremely delicate lattice-like membrane of amalgamated six-rayed spicules, which likewise extends over the ostia. The basal, or root, portion of the sponge is nodose and without ostia or canals. Type species *Tremadictyon* (*Scyphia*) *reticulata*, Goldfuss, sp. ('Petref. Germ.' vol. i, p. 11, pl. iv, figs. 1 *a*—*d*).

The above description is taken from that given by Von Zittel, based on specimens from the Upper Jura of Würtemberg, in which the skeletal structures have been preserved. The earliest recorded appearance of the genus is by Dunikowski, in the Lower Lias of Schafberg, near Salzburg ('Denkschriften der k. Akad. Wissensch. Wien,' vol. xlv, 1882, p. 179, pl. iv, figs. 42, 43); it occurs abundantly in the Swiss Jura, as well as in the Upper Jura of Würtemberg.

1. TREMADICTYON SPARSUM, *Hinde*, sp. nov. Plate X, figs. 1, 1*a*.

Only fragments of this species are known, they indicate that the sponges were open cup-shaped, having walls from 4 to 12 mm. in thickness; the surface ostia are oval, ranging from 1·5 mm. to 3 mm. in length, and the mesh-walls between

them are from 1 mm. to 2 mm. in thickness. The spicular mesh, as seen in thin sections (Pl. X, fig. 1 *a*) is lax and irregular, bounding very unequal interspaces.

One of the largest fragments met with, figured on Pl. X, fig. 1, appears to be the upper portion of a large cup-shaped specimen, probably 150 mm. in diameter. Smaller fragments are not at all uncommon, but they are all in very unfavorable preservation; usually the ostia of only one surface are exposed, whilst the spicular structure is invariably replaced by calcite and very imperfectly shown. In the size and arrangement of the ostia the specimens resemble some fragments from the Upper Jura, which have been figured by Quenstedt as portions of *Tremadictyon reticulatum*, Goldf. ('Petrefactenkunde Deutschlands,' pl. cxv, figs. 1 *i*, 2 *i*), but it may be doubted if these really belong to the same species as Goldfuss's type. Further, the spicular mesh in the fragments from the Inferior Oolite (Pl. X, fig. 1 *a*), appears distinctly more irregular than in *T. reticulatum* from the Upper Jura of Germany, of which a small piece is figured for comparison (Pl. X, fig. 3).

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Burton Bradstock, near Bridport, Dorset (Walton Coll., Woodwardian Museum, Cambridge).

2. Tremadictyon incertum, *Hinde*, sp. nov. Plate X, figs. 2, 4.

Cup- or funnel-shaped sponges with thick walls ranging from 18 to 30 mm. in thickness; the ostia of the outer surface are oval in form, and from 2 mm. to 4 mm. in diameter. The spicular mesh is very irregular and open. Fairly complete examples as well as large fragments of this species are known, but both the canal and spicular structures in all of them are now so indistinct that it is difficult to determine whether they properly belong to this genus or not.

The most complete specimen (Pl. X, fig. 4) is funnel-shaped, 125 mm. in height, by 90 mm. in width at the summit. Near the upper margin there are a few oval ostia shown, which appear to have been disposed closely in alternate rows; the rest of the surface is unevenly weathered, and no dermal layer is preserved, though in some places the irregular mesh of the skeleton can be seen. In sections of the sponge wall the spicular skeleton appears as an irregular network with very unequal meshes; the nodes are compact, but there are small apertures in some of them arising from the unequal deposition of the silica near the nodes. The canal structure cannot be made out with certainty. The interior of the sponge has been completely filled with the matrix of calcareous ooze, and the skeleton has been wholly replaced by calcite.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Coll. G. J. Hinde.)

Genus.—CALATHISCUS, *Sollas.*

1883. Quart. Journ. Geol. Soc., vol. xxxix, p. 546.

Tubular, subcylindrical, or horn-shaped sponges; the interior cloacal cavity extending nearly from the base. The ostia of the outer surface circular to oval, numerous, disposed either irregularly or sometimes in rows alternately; the ostia on the inner surface distinctly larger than those on the outside of the wall. Canals sinuous, interdigitating with each other in the substance of the wall. The skeletal meshwork very irregular; some of the nodes are compact, whilst in others they are partially perforate but not regularly octahedral in character, as in *Ventriculites.*

3. CALATHISCUS VARIOLATUS, *Sollas.* Plate XI, figs. 1, 1 *a*—1 *c.*

1883. CALATHISCUS VARIOLATUS, *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, p. 546, pl. xxi, figs. 17—20.

The sponges are straight or slightly sinuous, horn-shaped, irregularly swollen at intervals, the base bluntly pointed or with a slight expansion. They range from 120 mm. to 160 mm. in height, and about 40 mm. in diameter in the upper portion. The walls are from 5 mm. to 6 mm. in thickness. The ostia of the outer surface are circular to oval in form, and vary from 1 mm. to nearly 2 mm. in diameter, whilst the interspaces between are about the same in width. The disposition of the ostia is masked by the weathering of the surface; in some places they appear to be irregular whilst in others they are alternate in vertical rows. The ostia of the cloacal surface are about 2 mm. in diameter. The skeleton in some places forms subquadrate meshes with compact nodes, in others the nodes show perforations, and there is no definite arrangement.

As in other siliceous sponges from the Inferior Oolite, the skeleton has been completely replaced by calcite. The specimens are not uncommon.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne.)

Genus.—Craticularia, *Zittel.*

1877. Studien über fossile Spongien, I. Abhandlung der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. i, p. 46.

Syn.—Scyphia, *Auct.* (in part); Cribrospongia, *d'Orbigny*, *F. A. Roemer* (in part); Goniospongia, *d'Orbigny* (in part); Dictyonocœlia, Cribrocœlia, Goniocœlia, *Etallon* (in part); Diplostoma, Dendrospongia, *F. A. Roemer* (in part); Eucoscinia, Desmoscinia, Phragmoscinion, Rhabdocnemis, Laocœtis, Hemicœtis, Brachiolites, *Pomel* (in part); Textispongia, Clathrispongia, *Quenstedt* (in part).

Sponges cup- or vase-shaped, cylindrical, tubular, simple, or branching. Both the outer and inner surface of the sponge-wall with numerous round or oval ostia disposed in regular vertical and transverse rows crossing each other at right angles; occasionally the ostia of one surface are disposed in longitudinal furrows. The radial canals are straight and terminate blindly, those from opposite surfaces alternating with each other. Skeleton very regular, forming equal meshes, with compact nodes. Occasionally there is a delicate dermal layer similar to that in *Tremadictyon*. The type species is *Craticularia* (*Scyphia*) *parallela*, Goldfuss, sp. ('Petref. Germ,' vol. i, p. 8, pl. iii, fig. 3). This genus is fairly common in the Jurassic strata of Germany and in the Cretaceous of this country.

4. Craticularia clathrata, *Goldfuss*, sp. Plate XI, fig. 5.

1826–33.	Scyphia clathrata,	*Goldfuss.*	Petref. Germ., p. 8, pl. iii, figs. 1 *a*, *b*.
1877.	Craticularia clathrata,	*Zittel.*	Studien, i, p. 46; Neues Jahrbuch, p. 355.
1878.	Scyphia —	*Quenstedt.*	Petref. Deutschl., vol. v, p. 72, pl. cxvii, figs. 22—24.
1883.	Craticularia —	*Hinde.*	Cat. Foss. Sponges, p. 94.

The only example of this species from British rocks, so far as yet known, is the lower portion of a vasiform specimen, 73 mm. in height by 49 mm. in width. The wall at the upper margin is 13 mm. in thickness. The roughened outer surface shows regularly-disposed oval ostia from 2 mm. to 3 mm. in width; the vertical rows are separated by nodose ridges, about 3 mm. in width. The ostia of the inner surface of the wall are situated in longitudinal furrows. The skeletal meshwork, as shown on a polished surface, is extremely regular, the sides of the

subquadrate meshes are about ·3 mm. in length. The original skeleton has been wholly replaced by calcite.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Walton Coll., Woodwardian Museum.) It also occurs in the White, or Upper, Jura of Würtemberg, and at Randen, near Schaffhausen.

5. Craticularia foliata, *Quenstedt*, sp. Plate X, fig. 6—6 *b*.

1878. Textispongia foliata, *Quenstedt*. Petref. Deutschl., vol. v, p. 64, p. cxvii, figs. 7 *a*, *i*, *x*.
1883. Leptophragma fragile, *Sollas*. Quart. Journ. Geol. Soc., vol. xxxix, p. 545, pl. xx, figs. 10, 11, 11 *a*.

Entire form of sponge unknown, probably platter-shaped; the specimens consist of irregular broken fragments of a delicate plate-like wall, from 30 mm. to 50 mm. across, and from 2 mm. to 3 mm. in thickness. Both surfaces of the wall exhibit small, nearly circular ostia, about ·4 mm. wide, separated by interspaces of nearly equal width. The ostia are very regularly disposed so as to give an appearance of a minute quadrate reticulation to the surface. The canals extend at right angles nearly through the wall, and terminate blindly. The skeletal meshwork is very regular (Pl. X, fig. 6 *b*); the distance between the nodes is about ·125 mm., measured in thin sections of the wall.

These fragments agree so closely with those described and figured by Quenstedt, from the Upper Jura, below Mühlheim on the Danube, that there can be no doubt they belong to the same species. This author mentions that flattened fragments of the wall, a foot in width, occur in the shaly strata of this locality, so that the sponge must have reached considerable dimensions. Prof. Sollas did not adopt Quenstedt's name for this species, because, as he states, no magnified representation of the skeletal network was given; but, as a matter of fact, this has been figured by Quenstedt (l. c., fig. 7 *x*) and it corresponds closely with that of the British specimens.

Prof. v. Zittel has called attention to the fact that the spicular structure of the sponges with small ostia, which Quenstedt has ranged under *Textispongia*, is of a precisely similar character to that of the sponges with large ostia, placed by the same author under *Clathrispongia*, and that, consequently, both these divisions can be well included under *Craticularia* ('Neues Jahrbuch,' 1877, p. 708).

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock (Coll. Rev. G. F. Whidborne); and at Shipton Gorge (Coll. Mr. E. A.

Walford), Dorset. Also from the White Jura below Mühlheim, on the Danube (Quenstedt).

Genus.—Verrucocœlia, *Etallon.*

1859. Études paléontologiques sur les terrains jurassiques du Haut Jura. Monographie de l'étage Corallien. Mémoires de la Société d'Emulation du département du Doubs, s. iii, vol. iii, 1859, p. 537.

Syn.—Scyphia, *Auct*; Eudea, *d'Orbigny* (in part); Polycœlia, Cylindrospongia, *F. A. Roemer* (in part); Oncolpia, Rhabdocœlia, Plectodocis, Emplocia, Matoscinia, *Pomel;* Mastospongia, *Quenstedt* (in part); Mastodictyum, Plectospyris, *Sollas.*

Sponges compound, branching; the branches in some instances radiating from a central tube or cavity, in others they spring from a common base and inosculate with each other. The ostia of the walls are numerous, small, and without regular arrangement; canals nearly straight, those from opposite sides of the wall alternating with each other. The skeletal mesh regular, with compact nodes, as in *Craticularia.* The type species is *Verrucocœlia* (*Scyphia*) *verrucosa*, Goldfuss ('Petref. Germ.,' vol. i, p. 91, pl. xxxiii, figs. 8 *a*—*e*), from the middle beds of the White Jura, near Streitberg.

6. Verrucocœlia Whidborni, *Sollas*, sp. Plate XI, figs. 2, 2 *a*.

1883. Mastodictyum Whidborni, *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, pl. xx, figs. 7—9.

The type and hitherto the only known example of this species has a fan-shaped outline, measuring 110 mm. in width by 90 mm. in height; the basal portion is incomplete, but from it several main tubular branches are given off which subdivide and terminate in truncate, conical, teat-like tubes projecting either directly or obliquely upwards, whilst the direction of the main branches is nearly horizontal. These projecting tubes range up to 8 mm. in diameter; some are nearly sessile, whilst others extend about 16 mm. above the level of the basal branches, their summit apertures are from 2·5 mm. to 4 mm. in width. The ostia of the outer surface are about ·5 mm. in width. The spicular mesh is regular, and the distance between the nodes about ·15 mm.

This specimen was made, by Prof. Sollas, the type of a distinct genus, but in its mode of growth and in the character of the canals and spicular structure it sufficiently resembles some of the forms included by Prof. Zittel under *Verrucocœlia* to be included in this genus. The form appears to be very rare.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne.)

7. Verrucocœlia elegans, *Sollas*, sp. Plate XI, figs. 3, 3 *a*.

1883. Plectospyris elegans, *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, p. 545, pl. xx, figs. 12—14.

The typical species, based on a single fragmentary specimen, consists of a small group, 50 mm. wide by 30 mm. in height, of short branching tubes, frequently intergrowing laterally with each other; the basal portion of these tubes is not preserved, so it cannot be told whether they originate from a common hollow base or not. The tubes are usually compressed, from 5 mm. to 8 mm. in diameter; their walls are from 2 mm. to 3 mm. in thickness, and slightly thickened at the summits. The ostia of the outer surface are closely but irregularly disposed, and about ·5 mm. in width; those of the inner surface appear to be arranged in longitudinal grooves. The skeletal mesh is regular, and the nodes are about ·16 mm. apart.

This specimen has also been made the type of a new genus, but it does not seem to be generically distinct from *Verrucocœlia.*

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne.)

8. Verrucocœlia major, *Sollas,* sp. Plate XI, fig. 4.

1883. Plectospyris major, *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, p. 546, pl. xx, figs. 15, 16.

The only known example of this species is contained in a small compact nodule of limestone, the upper surface of which shows the apertures of several tubes, with flattened, somewhat thickened margins. The tubes are from 8 mm. to 11 mm. in diameter, their walls 3·5 mm. in thickness, and the inner cavity 3·5 mm. in width.

The ostia are not shown. The spicular structure is closely similar to that of the preceding species, from which it mainly differs in the larger size of the tubes. So far as can be judged from the surface, the arrangement and character of the tubes in this form are very similar to those of *Verrucocœlia* (*Mastospongia*) *gregaria*, Quenstedt ('Petref. Deutschl.,' vol. v, p. 148, pl. cxxii, figs. 8—10) with which it also agrees in spicular structure.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne.)

Genus.—Stauroderma, *Zittel.*

1877. Studien über fossile Spongien, I. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. i, p. 53.

Syn.—Scyphia, *Auct;* Cribrospongia, *d'Orbigny* (in part).

Infundibuliform or platter-shaped sponges with thick walls. The upper or inner surface with numerous apertures of cloacal tubes, whilst the under or outer surface of the wall is reticulate as in *Tremadictyon.* The canals pass obliquely through the wall, and after extending a distance beneath the inner surface open into the cloacal tubes. Skeleton mesh irregular, the nodes thickened or irregularly widened. Both surfaces of the wall furnished with a dermal layer consisting of moderately-sized, cruciform spicules cemented together. The type species is *Stauroderma* (*Spongites*) *Lochense*, Quenstedt ('Der Jura,' p. 669, pl. lxxxi, fig. 96), from the Upper Jura of Streitberg, Germany.

9. Stauroderma explanatum, *Hinde*, sp. nov. Plate X, figs. 5, 5 *a*.

The entire form of sponge unknown; the specimens consist of flattened plate-like fragments, some of which are 120 mm. in length by 80 mm. in width, whilst the walls reach to 16 mm. in thickness. The upper surface is smooth, with nearly circular oscular apertures about 4 mm. in diameter, regularly arranged in quincunx, about 10 mm. apart. The under surface is concealed by matrix. The spicular mesh of the interior, as seen in thin sections of the wall, is very irregular; the nodes are widened by unequal deposition of silica, so that the Hexactinellid character is completely masked. Here and there on the smooth upper surface, traces of the dermal layer can be distinguished. It consists of

cruciform spicules of moderate dimensions, about 1 mm. across; the spicules have no definite arrangement and their rays overlap each other irregularly. These spicules probably have a fifth ray which extends into the wall. In comparison with the specimens of *S. Lochense*, Quenstedt, sp., from the Upper Jura of Germany, the present form has the oscules of the upper surface smaller and more closely arranged and the wall does not attain the same thickness.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne.)

Sub-order.—LITHISTIDÆ.

Family.—Rhizomorina.

Genus.—Platychonia, *Zittel.*

1878. Studien über fossile Spongien, II. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. i, p. 114.

Syn.—Spongites, Planispongia, *Quenstedt* (in part); Amorphospongia. *d'Orbigny* (in part).

Sponges with plate-like walls, either ear-shaped, undulating, or variously folded, less often cup- or platter-shaped. Both outer and inner surfaces of the wall with pores or ostia. Canal system scarcely distinguishable, in some instances apparently entirely limited to the labyrinthic interspaces formed by the skeleton, in others there are capillary-like tubes extending the entire length of the sponge and giving to it a fibrous, or radiate, appearance. The spicules consist of a main axis, usually curved; from the sides and ends of this spinous branches are given off. In some cases the lateral branches are so developed that the spicules can hardly be distinguished from the four-rayed Tetracladine spicules. The spicules are loosely interwoven so as to form an irregular meshwork.

The typical species is *Platychonia* (*Spongites*) *vagans*, Quenstedt, sp. ('Der Jura,' p. 679, pl. lxxxii, fig. 8), from the Upper, or White, Jura of Germany. As a rule, the sponges of this genus are so poorly preserved, that but little more than their form and mode of growth can be ascertained.

10. Platychonia Brodiei, *Sollas*. Plate XII, figs. 4, 4 *a*.

1885. Platychonia Brodiei, *Sollas*. Proc. Royal Dublin Society, N. S., vol. iv, p. 443, pl. xxi, figs. 4—6.

The only example of this species known is sessile, pouch- or fan-shaped, with incurved sides; it measures 55 mm. in height by 33 mm. across. Both the outer and inner surfaces are somewhat uneven, with slight rounded elevations and depressions. The ostia of the convex outer surface are subcircular, from ·2 mm. to .3 mm. wide; those of the inner surface are very indistinctly shown, but according to Professor Sollas they range up to ·4 mm. in diameter. There is no distinct canal system beyond that in the irregular interspaces of the skeleton. The spicules are slender, loosely connected together, without definite arrangement; they are almost entirely replaced by calcite.

Distribution.—Marlstone of the Middle Lias at Ilminster, Somerset. (Coll. Rev. P. B. Brodie.)

11. Platychonia elegans, *Sollas*. Plate XII, figs. 2—2 *b*.

1883. Platychonia elegans, *Sollas*. Quart. Journ. Geol. Soc., vol. xxxix, p. 547, pl. xxi, figs. 22—25.
Cf. 1858. Platychonia (Spongites) vagans, *Quenstedt*. Der Jura, p. 679, pl. lxxxii, fig. 8.

Sponges growing in the form of irregular undulating plates, from 5 mm. to 8 mm. in thickness, with curved and occasionally lobate margins. Surfaces uneven, with irregular hollows and ridges. When weathered, the upper surface exhibits a very fine reticulate network, with small circular or irregular pores, or ostia, from ·5 mm. to ·7 mm. in width; and a similar structure is present on the more uneven under-surface.

These sponges sometimes grow directly attached by the under surface of the wall to other sponges, as in the example figured (Pl. XII, fig. 2), where the sponge is growing on the Hexactinellid *Calathiscus variolatus*, Sollas; in other instances they have a short, blunted stem, or base, which is free. The specimens range from 50 mm. to 125 mm. in width. The originally siliceous skeleton has been replaced by calcite in all the specimens, and as a consequence the form of the individual spicules has been to a considerable extent obliterated, this more particularly happens where the branching extremities of the spicules interlock

together, and they are now only indicated in thin sections by patches of calcite with irregular outlines (Pl. XII, fig. 2 *b*). This will be better understood by comparison with the figures of a portion of the spicular mesh of a closely allied species, *Platychonia vagans*, Quenstedt, sp., in which the spicules retain their siliceous structure (Pl. XII, fig. 3). In its mode of growth and in the thickness of the walls this species has a considerable resemblance to *P. vagans*, but owing to its condition of preservation a close comparison is impracticable.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne; G. J. Hinde.)

12. PLATYCHONIA TENUIS, *Hinde*, sp. nov. Plate XII, figs. 6, 6 *a*.

Sponges consisting of thin plate-like walls, either ear-shaped or convolute; the walls are from 3·5 mm. to·5 mm. in thickness; the surfaces are fairly even though with occasional depressions. The outer surface has small circular or irregular ostia from ·2 mm. to ·5 mm. in width. The spicular mesh is of the same character as in *P. elegans*, but the component spicules are apparently smaller. The specimens range from 35 mm. to 68 mm. in width.

This species differs from *P. elegans* in its thinner walls, more even surfaces, and more delicate spicules.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock, and at Shipton Gorge, Dorset. (Coll. G. J. Hinde; E. A. Walford.)

13. PLATYCHONIA AFFINIS, *Hinde*, sp. nov. Plate XII, figs. 5, 5 *a*.

The only specimen referred to this species is platter-shaped, with an oval outline, 90 mm. across; it has a short, inversely-conical base, whilst the margins are rounded and in places thickened and recurved. The walls range from 5 to 10 mm. in thickness. The under or outer surface exhibits small rounded pores, or ostia, about ·4 mm. in width, bounded by the skeletal fibres; in places on the upper surface there are traces of horizontal canals from ·5 mm. to ·7 mm. in width. The skeletal mesh consists of fibres of loosely-arranged spicules which are now entirely replaced by calcite. In form and mode of growth and in the more distinctly fibrous character of the spicular mesh this species is distinguished from the preceding.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Burton Bradstock. (Coll. G. J. Hinde.)

Genus.—LEIODORELLA, *Zittel.*

1878. Studien über fossile Spongien, II. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. i, p. 113.

Syn.—Planispongia, Tragos, *Quenstedt* (in part).

Sponges with plate-like, ear-shaped, undulating walls, sometimes nodose or incrusting. Both surfaces of the wall covered with a smooth, apparently compact dermal layer which is perforated by oscules, and from these short curved canals extend into the wall and branch at their extremities. The skeleton consists of a moderately close mesh of spinous branching lithistid spicules with short simple axial canals. The dermal layer consists of small much-branched spicules. The typical species is *Leiodorella expansa*, Zittel, from the Upper Jura of Wodna, near Cracow. (' Studien,' ii, p. 113, pl. ii, fig. 5; pl. iii, fig. 11.)

14. LEIODORELLA CONTORTA, *Hinde*, sp. nov. Plate XII, figs. 1, 1*a*.

Sponge growing in the form of an irregularly undulating, somewhat fan-shaped expansion, about 90 mm. in width by 60 mm. in height, with walls from 7 mm. to 10 mm. in thickness. The under surface is covered with a smooth dermal layer, which is penetrated by numerous irregularly disposed, sub-circular oscules from 1·25 mm. to 1·75 mm. in width and from 2 mm. to 3 mm. apart. The oscules do not now project beyond the surface, their margins are uneven, and they appear to serve as outlets for a variable number of canals, usually from two to four, which open into them. The upper surface of the sponge-wall is, to a great extent, concealed by matrix, but on grinding this away some sinuous horizontal canals are exposed, which may have extended beneath a dermal layer. The spicular mesh has been replaced by calcite, so that a thin section of the wall only shows a confused mass of interwoven spicules which form the fibres bordering the canals. In its appearance and general structure this sponge corresponds with some of the forms of *Platychonia* already described, but it can be readily distinguished from these by the smooth dermal layer with its numerous oscules. In the only other species of this genus yet described, *L. expansa*, Zittel, the oscules markedly project and they are less closely arranged than in the present form.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff-section at Burton Bradstock. (Coll. G. J. Hinde.)

Family.—ANOMOCLADINA.

Genus.—MELONELLA, *Zittel.*

1878. Studien über fossile Spongien, II. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. i, p. 134.

Syn.—Siphonia, *Goldfuss*, *Quenstedt* (in part); Emploca, Taxoploca, *Sollas;* Emploca, *Vosmaer*.

Subspherical, hemispherical, or ovate sponges; the lower portion either widened or supported on a short stem. Cloacal cavity deep, funnel-shaped, with the apertures of the excurrent canals arranged in longitudinal rows. The excurrent canals follow the curved contour of the sponge and open into the cloacal tube; the incurrent canals extend from the ostia on the surface in an obliquely curved direction towards the centre of the sponge. The skeleton consists of a close mesh of connected spicules of the Anomocladina type, like those of the genus *Cylindrophyma*, Zittel, in which, from twin nodes connected by a short rod-like axis, several arms or rays are given off which expand at the ends and connect with adjoining nodes (Part I, p. 71, fig. 5 *b*). The lower portion in some specimens is enveloped in a dermal layer.

The type species of this genus is *Melonella* (*Siphonia*) *radiata*, Quenstedt ('Der Jura,' p. 679, pl. lxxxii, fig. 13); from the Upper Jura of Heuberg. There is a close similarity in the canal system of this form to that of the Cretaceous genus *Siphonia*, but the spicular structure is markedly different.

15. MELONELLA OVATA, *Sollas*, sp. Plate XIII, figs. 1, 1 *a*—*c*.

1883. EMPLOCA OVATA, *Sollas*. Quart. Journ. Geol. Soc., vol. xxxix, p. 542, pl. xx, figs. 1—6.
1887. — — *Vosmaer*. Porifera, Bronn's Klassen und Ordn. des Thier-Reichs, Bd. ii, p. 257.
1888. TAXOPLOCA — *Sollas*. Challenger Report, Zoology, vol. xxv, p. xxviii.

Sponges ovate to sub-cylindrical, sessile, attached directly by their bases to shells or other bodies. Of the two specimens known one is 42 mm. in height by 30 mm. in diameter, whilst the other is 45 mm. by 22 mm. No dermal layer is present. The cloacal aperture is from 5 mm. to 6 mm. in diameter; the ostia of the surface are numerous, about ·5 mm. in width, and separated from each other by about the same interval. The canal structures are only partially shown in the specimen, which has been longitudinally sectioned; both the incurrent and excurrent canals appear to be nearly of an equal width, about ·5 mm. The

spicular mesh, which has been replaced by calcite, or in places dissolved away, leaving empty spaces in the matrix, is of a very close character; in thin sections it appears as a very fine reticulation, the nodes being connected by short rays; sometimes the meshes are subquadrate in outline. On the weathered surface of the sponge the minute spherical nodes of the spicules with their connecting rays stand out prominently and can be distinguished under the microscope (Pl. XIII, fig. 1 *c*). On comparing this structure with that of *Melonella radiata*, Quenstedt, of which there are several specimens in the British Natural History Museum, in the same condition of preservation, a very close resemblance is apparent. As in all the specimens of *Melonella*, the spicules in these sponges have been replaced by calcite. I have figured two of the siliceous spicules of *Cylindrophyma milleporatum*, Goldfuss, sp. (Pl. XIII, figs. 2, 2 *a*), for comparison with those of the present form.

This species was described by Prof. Sollas as the type of a new genus of Hexactinellid sponges characterised by having a canal system like that of the Lithistid genus *Siphonia*. There can be no doubt, however, that its spicular structure is really of the Anomocladina type, and that it is closely related to *Melonella radiata*. The mistake in its identification has arisen from the fact—as already remarked by Prof. v. Zittel—that the spicular structure of this group of Lithistids has often a deceptive resemblance to that of certain Hexactinellids, and more especially is this the case when the silica of the spicules has been replaced by calcite. Independently of the spicular structure, the general build and the character of the canal system in these sponges are sufficient to betray their relationship to typical Lithistids.

Distribution.—Inferior Oolite. *Humphresianus*-zone at Dundry Hill, near Bristol. (Coll. Rev. G. F. Whidborne.)

Sub-order.—TETRACTINELLIDÆ.

Genus.—Pachastrella.

16. Pachastrella antiqua, *Moore*, sp. Plate XIII, figs. 3, 4.

1867. Grantia antiqua, *Moore.* Quart. Journ. Geol. Soc., vol. xxiii, p. 538, pl. xvi, figs. 33, 34.
1878. Pachastrella antiqua, *Carter.* Ann. and Mag. Nat. Hist., ser. 5, vol. i, p. 418.
1883. — — *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, p. 542, note.
1883. — — *Hinde.* Cat. Foss. Sponges, B. Mus., p. 209, note.

Form of sponge unknown; the species is based on detached three- and four-rayed caltrop spicules; the rays in a small specimen are ·35 mm. in length by

.09 mm. in thickness, whilst in the largest form noticed they are 1 mm. in length by ·25 mm. in thickness. The rays are relatively robust, gradually tapering, with blunted ends.

These spicules were first noticed by the late Mr. Charles Moore, who states that they occur in such numbers in the Liassic limestones of South Wales as to constitute a material portion of the substance of the rock. As they are now of calcite Mr. Moore supposed that they belonged to a Calcisponge and placed them under the genus *Grantia,* Fleming, but Mr. Carter subsequently pointed out that from their form and proportions they must have been originally siliceous, and that they probably belonged to *Pachastrella.* The spicules are scattered irregularly in the grey liassic limestone, and weather out on the surface of the rock as minute whitish bodies, which can occasionally be obtained quite detached. In sections of limestone of the same age at Shepton Mallet these caltrop spicules are intermingled with accrate and trifid spicules belonging to other sponges (Pl. XIII, fig. 4). In all, the silica has now been replaced by granular calcite. The same forms also occur abundantly in beds of chert at Portland, similarly intermingled with other spicules. In this deposit they are siliceous, and sometimes they are found quite detached in a matrix of decayed chert.

Distribution.—Lower Lias conglomerate and limestone at Brocastle, Cowbridge, Southerndown, Glamorganshire, South Wales; Shepton Mallet, Somersetshire; Portland beds, in the cherty bands below the "Whit bed," on the Isle of Portland, and at Upway near Weymouth (Geol. Surv. Museum, Jermyn Street).

Genus.—GEODITES, *Carter.*

17. GEODITES, sp. (*a*). Plate XIII, fig. 5.

Trifid spicules with stout, straight, elongate shaft, and simple head-rays projecting obliquely forwards. In the specimen figured the shaft is 2·25 mm. in length by ·15 mm. in thickness, whilst the head-rays, of which only one is preserved entire, are ·45 mm. in length by ·1 mm. in thickness. These trifid spicules are fairly common in beds of Portland chert, associated with the *Pachastrella* spicules described above, but they are usually in a very fragmentary condition. They belong to a common type of zone-spicule, and differ but slightly in form and size from the trifid spicules of *Geodites antiquus*, from the Carboniferous limestones of Scotland and North Wales (Part II, p. 150, Pl. V., figs. 3 *a*—*d*); similar forms likewise occur in sponges from the Upper Chalk, and in existing sponges as well.

Distribution.—Portland beds; in the cherty bands below the "Whit bed," Isle of Portland.

18. Geodites, sp. (*b*). Plate XIII, fig. 5 *a*.

Trifid spicules, with straight, gradually tapering shafts, and short, nearly horizontally extended head-rays. Shaft 1·87 mm. in length by ·05 mm. in thickness; the head-rays are about ·102 mm. in length. Accompanying these are nearly straight, acerate spicules, 2 mm. in length by ·08 mm. in thickness, which probably belong to the same species. These spicules are now replaced by calcite; they occur in a limestone matrix infilling a species of *Tremadictyon*.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the cliff at Burton Bradstock. (Coll. G. J. Hinde.)

Family.—Rhaxellidæ, *Hinde.*

Sponges with walls of continuous, anastomosing, plate-like laminæ or trabeculæ, composed of agglomerated globate spicules of the same character as those forming the crust and axis of the existing genus *Placospongia*, Gray. (' Proc. Zool. Soc.,' 1867, p. 127.)

Genus.—Rhaxella, *Hinde.*

1890. Quart. Journ. Geol. Soc., vol. xlvi, p. 59.

Palmate, flabellate, or rarely funnel-shaped sponges; the laminated walls enclosing labyrinthic, intercommunicating channels and lacunæ, which open at the surface by sub-circular or elongate apertures.

19. Rhaxella perforata, *Hinde.* Plate XIII, figs. 7, 7 *a—f*.

1890. Rhaxella perforata, *Hinde.* Quart. Journ. Geol. Soc., vol. xlvi, p. 59, pl. vi.
1891. — — *Rauff.* Neues Jahrb. für Mineralogie, &c., Bd. ii, p. 370.
1891. — — *Blake.* Proc. Geol. Assoc., vol. xii, p. 134.

These sponges occur as more or less weathered-out masses of irregular outlines, sometimes palmate or fan-shaped, at others with a deep funnel-shaped central cavity. All the specimens are imperfect, the largest measures 140 mm. in height by 80 mm. in width. The walls range up to 14 mm. in thickness, they consist of

plates or trabeculæ from ·5 mm. to 4 mm. in thickness, disposed so as to leave irregular channels and open spaces between them. The outer surface of the wall is smooth or slightly ribbed, and it is perforated by ovate or narrow slit-like apertures from 1 mm. to 9 mm. in width, whilst the interspaces between the plates, as seen in a transverse section of the wall, vary in width from 1 mm. to about 4 mm. (Pl. XIII, fig. 7 *b*). The wall-plates are entirely composed of small globate spicules, closely aggregated together (Pl. XIII, fig. 7 *c*). They are ellipsoidal or subspherical in form, with a small depression or hilum, which gives them a kidney-shaped appearance; in size they range between ·11 mm. and ·15 mm. in diameter; some smaller forms are, however, not more than ·08 mm. in thickness. As in the globates of existing species of *Geodia* and *Placospongia*, these fossil forms are composed of numerous minute spicular fibres or rods in close contact, which radiate from the centre of the spicule and terminate at the surface as small subcircular spots, ·002 mm. in width, regularly arranged in quincunx (Pl. XIII, figs. 7 *e*, 7 *f*). Many of these globates are nearly as perfect as those of existing sponges, and their structures are readily seen when examined in glycerine under the microscope, but the surfaces in others are extensively corroded, and the central portion in these is often changed into banded layers of chalcedony. The spicules are now usually cemented together to form the wall-plates by a secondary deposit of silica, and in some instances in the central portion of the wall their distinctive forms have been obliterated, and they are merged in a mass of chalcedony.

The skeleton in these sponges as now preserved to us appears wholly to consist of the globate spicules, and in this respect they markedly differ from all other sponges. In *Placospongia*, Gray, the nearest allied genus, there is, in addition to an inner axis and surface plates of globate spicules, an intermediate skeleton of pin-shaped spicules which seem to be wanting in this fossil form.

Connected examples of this species are rare, but detached globate spicules of a similar character to those composing these sponges are extremely abundant, so as to form in some instances the principal constituents of beds of cherty rock of considerable thickness in the Lower Calcareous Grit of Scarborough and the neighbourhood. They were first noticed by Dr. H. C. Sorby ('Quart. Journ. Geol. Soc.,' vol. vii (1851), pp. 1—6); ('Proc. Geol. and Polytechnic Soc. Yorkshire,' vol. iii (1851), pp. 197—206, Pl. IV), and subsequently by Mr. J. F. Blake ('Monthly Microscopical Journal,' vol. xv, 1876, pp. 262—264), and by Mr. W. H. Hudleston ('Proc. Geol. Assoc.,' vol. v, 1877, p. 443). The spicules were at first referred to perforate foraminifera, and named by Mr. Blake *Renulina Sorbyana*. As it is highly probable that these detached spicules may belong to more than a single species, I have preferred to give a particular designation to the forms described above.

Distribution.—Corallian; Lower Calcareous Grit; zone of *Ammonites perarmatus*, Scarborough (Coll. York Museum); Coral Rag, Settrington, Yorkshire. (Coll. W. H. Hudleston).

Detached spicules, some of which may belong to this species though no connected specimens have as yet been found in the same beds, occur in the Coral Rag, North Grimston, Yorkshire (W. H. Hudleston), and on nearly the same horizon at Sturminster Newton, Dorsetshire, and at Hilmarton, near Colne, Wiltshire. (F. J. Blake.)

Sub-order.—MONACTINELLIDÆ.

Family.—Spongillidæ.

Sponges inhabiting fresh water, with skeletons of acerate or cylindrical spicules and gemmulæ or statoblasts furnished with small amphidisc spicules or spined acerates differing from those of the skeleton. This family is very widely distributed geographically, but very rarely occurs in the fossil condition.

Genus.—Spongilla, *Lamarck.*

1815. Animaux sans vertèbres, tom. ii, p. 98.

The skeletal spicules are spined or smooth acerates. The gemmules are globular and covered with a layer of minute, spined acerate spicules, disposed tangentially.

20. Spongilla Purbeckensis, *Young.* Plate XIII, figs. 6, 6 *a.*

1878. Spongilla Purbeckensis, *Young.* Geol. Mag., dec. ii, vol. v, p. 220, fig. *b.*
1883. — — *Hinde.* Cat. Foss. Sponges, p. 21, pl. i, fig. 9.

The only remains of this species yet known are masses of detached spicules preserved in nodules of chert, in association with valves of *Cypris* and other fresh-water organisms. The spicules are exceedingly numerous, so as to constitute the main portion of the chert in which they occur; they are slightly curved acerates, smooth usually, but Mr. Young has noted some which are minutely spined; they have an average length of ·37 mm., the longest measured are ·415 mm. and from ·02 mm. to ·03 mm. in thickness. In some the axial canal is visible. The spicules

are crowded together irregularly, so that in a section of the chert some are cut transversely or obliquely, whilst others show their complete forms (Pl. XIII, fig. 6). Hitherto no definite evidence of the much smaller gemmule spicules has been discovered, and consequently it is not quite certain that the skeletal spicules really belong to *Spongilla* or to the allied genus *Meyenia*. The accrate skeleton spicules are about half as large again as those of the existing *Spongilla lacustris*, Linn.

Distribution.—Chert in the Purbeck limestones at Stare Cove, near Lulworth, Dorsetshire (Coll. J. F. Young; Geol. Survey Museum, Jermyn Street).

ORDER.—CALCISPONGIÆ.

Family.—PHARETRONES.

Genus.—PERONIDELLA,[1] *Zittel.*

21. PERONIDELLA PISTILLIFORMIS, *Lamouroux*, sp. Plate XIV, figs. 1—1*d*.

1821. SPONGIA PISTILLIFORMIS, *Lamx.* Exposition méthod., p. 88, pl. lxxxiv, fig. 6.
1840–7. SCYPHIA PISTILLIFORMIS, *Michelin.* Icon. Zooph., p. 250, pl. lviii, figs. 4 *a*, *b*.
1854. — — *Morris.* Cat. Brit. Foss., p. 29.
1854. SPONGIA CYMOSA (?), *Morris.* Ibid., p. 30.
1859. POLYCŒLIA PISTILLOIDES, *Fromentel.* Mém. Soc. Linn. de Normandie, vol. xi, No. 2, p. 32, pl. i, fig. 8.
1878. PERONELLA PISTILLIFORMIS, *Zittel.* Studien, iii, p. 32.
1883. — REPENS, *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, p. 548, pl. xxi. fig. 31.
1883. — PISTILLIFORMIS, *Hinde.* Cat. Foss. Sponges, p. 165, pl. xxxiii, figs. 1, 1 *a*.

Sponges growing in bushy stocks or colonies, usually with a thickened procumbent base from which stems or branches are given off, which may either diverge or grow more or less in contact; in this latter case they frequently amalgamate laterally. The stems are either simple, or with lateral buds which

[1] Since the definition of this genus was given in Part II, p. 175, it has been discovered that the term "*Peronella*" was informally proposed by Dr. Gray in 1855, and adopted by A. Agassiz in 1872, for a genus or sub-genus of Echinoderms, and Prof. von Zittel has consequently proposed to modify the name for this genus of Calcisponges to "*Peronidella*."

form fresh branches, and sometimes again subdivide. The individual spongites are either subcylindrical, club-shaped, or ovoid, usually with a slight inflation at the summit, which is rounded, with a circular, well-defined cloacal aperture, usually from 1 to 1·5 mm., but sometimes 2 mm. in width. The colonies range from 25 to 63 mm. in width, and from 25 to 58 mm. in height; the spongites are from 3 to 6 mm. in thickness; just before division takes place some stems are 8 mm. in thickness.

The outer surface is only covered by a dermal layer in a narrow band wrapping round the bases of the stems and buds, and in certain places where there are indications of renewals of growth; the rest of the surface merely shows small oval or irregular apertures, bounded by the skeletal fibres, which at the surface are flattened. The wall fibres are comparatively stout, ranging from ·12 to ·33 mm. in thickness; they are composed of medium and small three-rayed spicules, perhaps also some four-rayed, very closely intermingled together (Pl. XIV, fig. 1 *c*). The rays vary from ·05 to ·22 mm. in length. The peculiar minute tuning-fork spicules are also present in the fibres (Pl. XIV, fig. 1 *d*). The outer portion of the fibres in some cases consists of a thin layer of filiform sinuous spicules, and occasionally similar spicules form a lining to the fibres bounding the cloacal tube.

There is considerable latitude both as regards the mode of growth and the size of the colonies and the individual spongites in the examples of this species, but there are so many gradational links that it is necessary to include all in one species. Both large and small spongites occur in the same colony, and on the same base may be found both cylindrical and club-shaped forms. Also in some colonies the stems diverge and extend outwards, whilst in others they are nearly upright and subparallel with each other.

This species appears to be very abundant in the Great Oolite, and a very fine series of specimens obtained from this formation at Hampton Cliffs near Bath are now in the Woodwardian Museum at Cambridge. The type of *Peronidella repens*, Sollas, is a fragment of a specimen of *P. pistilliformis*.

Distribution.—Great Oolite, Hampton Cliffs, near Bath; Stroud; Forest-Marble, Winsley, near Bath (E. A. Walford); Cornbrash, Langton Herring, near Weymouth.

Also in the 'Couche à polypiers,' at Langrune, Lebisey, Ranville, near Caen, France.

22. Peronidella tenuis, *Hinde*. Plate XIV, figs. 2, 2 *a*.

1883. Peronella tenuis, *Hinde*. Cat. Foss. Sponges, p. 166, pl. xxxiii, figs. 2, 2 *a*, 2 *b*.

Sponges growing in bushy masses of cylindrical or subcylindrical stems from 3 to 6 mm. in thickness. The main stems usually divide and give rise to two or three individuals which either grow in apposition, or slightly diverge from each other. The basal portion and the lower part of the stems are covered with a dermal layer. The summits are gently rounded, with a cloacal aperture about 1 mm. in width.

The skeletal fibres are slender, about ·1 mm. in width; near the outer surface they are somewhat closely arranged, but more open in the interior of the sponge-wall. The spicular structure is very imperfectly preserved, and the fibres now only show a series of three- or four-rayed spicules in the axial portion, enclosed by a fibrous crystalline layer.

Bushy masses of this species reach to 48 mm. in width by 35 mm. in height. From *P. pistilliformis* it is readily distinguished by the more slender character of the fibres and their different spicular structure. The type-specimen is in the British Natural History Museum.

Distribution.—Inferior Oolite. Pea-grit series, zone of *Ammonites Murchisonæ*, near Cheltenham. Also in the 'Couche à polypiers,' at Ranville, near Caen, France.

23. Peronidella Metabronnii, *Sollas*. Plate XIV, figs. 4—4 *f*.

1883. Peronella Metabronnii, *Sollas*. Quart. Journ. Geol. Soc., vol. xxxix, p. 548, pl. xxi, figs. 26, 27.

Sponges simple, subcylindrical or obconical in form, with a thickened, frequently expanded, foot-like base, straight or slightly curved, the summits flat or oblique, and with a relatively wide cloacal aperture. The walls are somewhat thin, so that the specimens are now frequently collapsed. The outer surface consists of an irregular mesh of fibres with very unequal interspaces (Pl. XIV, fig. 4 *d*). The cloacal tube is subcylindrical or funnel-shaped, its bounding wall of thickened fibres perforated by oval apertures about ·35 mm. in width, arranged alternately in vertical rows (Pl. XIV, figs. 4 *c*, 4 *e*). No special dermal layer is present. The

specimens range from individuals not more than 7 mm. in length to large forms 45 mm. in length by 11 mm. in diameter. In these latter the cloacal aperture is 6 mm. in width.

The skeletal fibres of the inner portion of the wall vary from ·1 to ·17 mm. in thickness, as measured in a transverse section; those of the outer surface are ·2 mm., whilst bordering the cloacal tube the fibres are ·25 mm. thick. The spicular structure is very indistinctly shown; it consists of three- and perhaps four-rayed spicules. Only occasionally can complete rays be distinguished; one of these measures ·27 mm. in length by ·03 mm. in thickness. The spicules vary considerably in size; they are irregularly but closely disposed in the fibres in the same way as in *P. pistilliformis*.

This species is fairly abundant in the Inferior Oolite. In all cases they are simple in their mode of growth, though occasionally one individual may have attached itself to the surface of another for support. Sometimes they appear to have grown on the surfaces of Hexactinellid sponges, for the under surface of the expanded base bears the imprint of cruciform spicules like those of the dermal layer of *Stauroderma*.

As remarked by Professor Sollas, there is a considerable resemblance in the form and mode of growth of this species to some of the forms of *Scyphia Bronnii*, Goldfuss, as figured by Quenstedt from the White Jura of Oerlinger and Nattheim ('Petref. Deutschl.,' vol. v, p. 183, pl. cxxiv, figs. 1—9). The main difference appears to be that in this latter form there are, according to Prof. v. Zittel, well-developed horizontal canals, which are not present in *P. Metabronnii*.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at the Cliff-section, Burton Bradstock (Rev. G. F. Whidborne; G. J. Hinde), Shipton George (E. A. Walford), Bradford Abbas (R. F. Tomes), Dorset.

24. Peronidella Waltoni, *Hinde*, sp. nov. Plate XIV, figs. 3—3 *c*.

Sponges forming colonies of subcylindrical stems, which frequently diverge from each other, and give off short, stumpy lateral branches. The main stems usually uneven with occasional swellings and nodosities; the summits are obtusely conical or truncate. They range from 20 to 74 mm. in length, and from 7 to 12 mm. in thickness. The walls are thick, varying between 2 and 4 mm., the cloacal tube subcylindrical, from 2·5 to 5 mm. in width; it extends throughout the length of the sponge. The aperture is circular or oval, 4 to 5 mm. in width, the margins entire. The outer surface in some specimens is fairly smooth, and perforated with

small circular apertures from ·3 to ·5 mm. in width, whilst in others this surface layer is absent or partially worn away, and then there are irregular apertures bounded by the fibres. The apertures leading into the cloacal tube are round or oval, and without definite arrangement.

A transverse section shows that the fibres bordering the exterior and the cloacal tube are much thicker than those of the inner portion of the wall (Pl. XIV, fig. 3 *c*). They range from ·16 to ·8 mm. in width. The structure is similar to that of *P. pistilliformis*, but the stouter fibres have a marginal layer of filiform spicules. The largest ray of a three-rayed spicule is ·3 mm. in length by ·025 mm. in thickness.

This species is fairly common, but it is rarely found perfect, the stems being usually in fragments. The form apparently nearest allied is *Peronidella cymosa*, Michelin, sp. (*non* Lamouroux) ('Iconogr. Zoophy.,' p. 249, pl. lviii, fig. 3 *a*), but the stems are smaller and more regular in their growth. Some of the forms included under *Peronidella clavarioides*, Lamouroux, sp. (' Expos. méthod.,' p. 88, pl. lxxxiv, figs. 8—10), are similar in form, but their fibres are more delicate, and the margins of the oscules are notched by surface canals.

Distribution.—Great Oolite. Hampton Cliffs, near Bath. The type-specimens are from the Walton Collection in the Woodwardian Museum, Cambridge.

25. Peronidella recta, *Hinde*, sp. nov. Plate XV, figs. 1—1*c*.

Sponges growing either singly or in small colonies of from two to four cylindrical pipe-like individuals with truncate summits, which range from 11 mm. to 20 mm. in length, and from 4 mm. to 7 mm. in thickness. The spongites usually grow from a thickened base, and they have generally been attached laterally to the spines of Echinoderms, which have now left an impress in a deep transverse furrow (Pl. XV, fig. 1). The outer surface is smooth with closely arranged fibres forming very irregular interspaces. The cloacal aperture is circular, about 1·5 mm. in width. The fibres, as seen in section, are from ·07 mm. to ·17 mm. in thickness : only the larger three-rayed spicules are shown with any distinctness ; their rays range up to ·2 mm. in length by ·035 mm. in thickness.

Distribution.—Corallian. Lower Calcareous Grit. Zone of *Ammonites perarmatus ;* at Suffield, near Scarborough. (Collected by Mr. S. Chadwick.)

26. Peronidella nana, *Hinde*. Plate XV, figs. 2—2 *g*.

1884. Peronella nana, *Hinde*. Quart. Journ. Geol. Soc., vol. xl, p. 780, pl. xxxv, figs. 2, 2 *a*.

Sponges small, for the most part growing singly, but occasionally two or three individuals are attached to a common base, globular, pear-shaped, or subcylindrical, attached either directly by a small basal expansion or supported on a short pedicle. The summits are rounded or subtruncate, with a circular or elongate cloacal aperture from 1 mm. to 2 mm. in width. The dermal layer is restricted to a narrow band round the base, or is sometimes altogether wanting. The specimens range from 4 mm. to 11 mm. in height, and from 3·5 mm. to 7 mm. in breadth.

The outer surface exhibits subcircular or irregular apertures, from ·1 mm. to ·5 mm. in width. The fibres are stouter in some specimens than in others, and the apertures somewhat larger. In transverse section of the wall the fibres of the outer surface are sometimes ·25 mm. in thickness, whilst those of the interior vary from ·05 mm. to ·14 mm. The cloacal tube extends nearly to the base of the sponge. The spicular structure of the fibres is very imperfectly shown : it appears mainly to consist of three-rayed spicules ; in some instances there is a marginal layer of filiform spicules.

This species was originally founded on two small specimens from the Richmond well-boring; numerous similar forms have since been obtained by Mr. E. A. Walford from Shipton Gorge. Amongst these there are certain differences in form and size, but they are all connected by intermediate variations, and seem to belong to one species.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, Dorset (Coll. E. A. Walford) ; and at Bradford Abbas (Mr. R. F. Tomes). Also in the Middle Oolite of the Richmond (Surrey) well-boring, at 1205 feet beneath the surface (Prof. J. W. Judd).

Genus.—Eusiphonella, *Zittel.*

1878. Studien über fossile Spongien, III. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, vol. xiii, pt. 2, p. 124.

Syn. Scyphia, *Goldfuss* (in part) ; Siphonocœlia, Discœlia, *Fromentel* (in part) ; Pareudea, *Etallon* (in part).

Sponges either simple or branching. The individual spongites are cylindrical, somewhat contracted below, thin-walled, with a wide tubular or funnel-shaped cloacal cavity, which extends from the base of the sponge. Wall of the cloacal

tube with elongated ostia, disposed in vertical rows which serve as the apertures of horizontal radial canals. The skeletal fibres are delicate, and form a loose meshwork. The outer surface provided with pores or small ostia. This genus may be distinguished from *Peronidella* by the presence of a system of horizontal canals. The type of the genus is *Eusiphonella* (*Scyphia*) *Bronnii*, Goldfuss, sp. ('Petref. Germ.,' vol. i, p. 91, pl. xxxiii, fig. 9), from the Upper Jura of Würtemberg.

27. Eusiphonella prolifera, *Hinde*, sp. nov. Plate XV, figs. 5, 5 *a*.

Sponges growing in large masses of frequently branching spongites, which radiate from a centre and extend both horizontally and vertically. The type-form is 170 mm. in length, 130 mm. broad, and 100 mm. in height. The individual spongites are cylindrical, straight or curved, with slightly swollen summits, which are, however, flat above. The longest individual measured is 27 mm., and they range from 6 mm. to 9 mm. in thickness. The branching usually takes place from the summit of the stems, which become tumid and give off two or three buds or short branches, which either grow parallel with the mother stem or slightly diverge from it. The spongites thus open all round the mass, and in the type-specimen there are more than one hundred of them.

The outer surface consists of minute scattered subcircular ostia, about ·4 mm. in width, with irregular porous interspaces between them. The cloacal apertures are from 2·5 mm. to 3 mm. in width. The interior surface of the cloacal tube has numerous delicate projecting longitudinal ridges, and the small elongate ostia are situated in the intermediate furrows. The spicular fibres are delicate, principally of three-rayed spicules, which, however, are very imperfectly shown in section; filiform spicules are present in places on the outer portion of the fibres. In transverse section the fibres range from ·08 mm. to ·18 mm. in thickness.

Besides its larger habit of growth, this species differs from *Eusiphonella* (*Scyphia*) *Bronnii,* Goldfuss, sp. (' Petref. Germ.,' vol. i, p. 91, pl. xxxiii, fig. 9), in its mode of branching and the relative thicker walls of the spongites. It may be doubted whether all the forms placed by Quenstedt under *E.* (*Scyphia*) *Bronnii* (' Petref. Deutsch.,' vol. v, p. 183, pl. cxxiv, figs. 1—15) should really be included in a single species; those which are termed *Scyphia Bronnii cæsposa* (l. c., figs. 10—12) approach the nearest to our species.

Distribution.—The form appears to be rare; the only specimen known is from the Great Oolite near Bath, and it is now in the British Natural History Museum.

Genus.—Corynella, *Zittel.*

1878. Studien über fossile Spongien, III. Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, vol. xiii, pt. 2, p. 125.

Sponges simple or compound. The individual forms are club-shaped, cylindrical, or subspherical, with thick walls. Their summits are truncate or arched. Cloacal cavity tubular or funnel-shaped, frequently not extending to the base of the sponge, but passing down into a bundle of vertical canals. The aperture or osculum usually with radiating furrows of open canals. Arched radial canals open into the cloacal cavity. Outer surface usually with small ostia of fine incurrent canals which have a downward oblique direction. Basal portion sometimes with a compact dermal layer. Skeletal fibres of three-rayed spicules; tuning-fork spicules and four-rayed spicules are present in some species.

In outer form the sponges of this genus greatly resemble *Peronidella*, but they are readily distinguished by the development of the canal system. It is doubtful if the Triassic forms included by v. Zittel in this genus possess a similar spicular structure to those from the Jurassic rocks described below.

28. Corynella lycoperdioides, *Lamouroux*, sp. Plate XV, figs. 3—3 *h*.

1821. Hallirhoa lycoperdioides, *Lamx.* Exp. méthodique, p. 72, pl. lxxviii, fig. 2.
1840–7. Siphonia lycoperdioides, *Michelin.* Icon. Zoophy., p. 251, pl. lviii, fig. 6.
1878. Corynella lycoperdioides, *Zittel.* Studien, iii, p. 126.
1883. — — *Hinde.* Cat. Foss. Sponges, p. 180.

Sponges simple, depressed globular, pear-shaped, or obtusely conical, rarely corrugate or lobate, supported on a short cylindrical stem, usually attached at its base to a fragment of shell or other organism. Small specimens are not more than 11 mm. in height by 6 mm. in thickness; the body of the largest example met with is 20 mm. in diameter. The stems do not appear to exceed 10 mm. in length.

At the summit the circular oscule slightly projects; it is from 2·8 mm. to 4 mm. in width: in full-grown specimens the rim is entire, but in others short furrows radiate from it; the surface of the sponge is usually smooth, and dotted irregularly with small oval ostia, from ·25 mm. to ·5 mm. in width, which are bounded by the flattened fibres; and in addition to these there are small, irregular,

pore-like openings between the fibres. When the surface is weathered it becomes rough, and occasionally is channelled by open furrows. These ostia and pores are present on the stem as well as on the body of the sponge. The cloacal tube extends down to the stem; its wall is well marked, and perforated at definite intervals by the apertures of the excurrent canals, which are about ·35 mm. in width.

The skeleton consists of a fairly close reticulation of narrow fibres from ·06 mm. to ·18 mm. in thickness, consisting of subequal three-rayed spicules interlaced together (Pl. XV, figs. 3 *d*, 3 *e*). The rays of these are about ·16 mm. in length. In addition to these, delicate tuning-fork spicules can occasionally be seen in the sections, which appear to be arranged nearly parallel with each other on the outer portion of the fibres (Pl. XV, figs. 3 *f*, 3 *g*). In the lower portion of one of the sponges there were bundles of these spicules filling the spaces between the ordinary fibres. One of these forms measured ·17 mm. in length. Within the same sponge there were also several sagittate four-rayed spicules (Pl. XV, fig. 3 *h*) quite distinct from those forming the fibres, and it is possible that these may belong to the wall of the cloacal tube. The only dermal layer in these sponges is a small band round the lower part of the stem.

These sponges are not uncommon in the Bradford Clay and the Cornbrash, and they retain their spicular structure in a very perfect condition.

Distribution.—Bradford Clay at Bradford-on-Avon, Wiltshire, and from the Box Tunnel, Bath. Cornbrash at Langton Herring, near Weymouth. Also from the "Calcaire à Polypiers" at Ranville and Benouville, near Caen, France. All the specimens figured are from the Walton Collection in the Woodwardian Museum, Cambridge.

29. Corynella elegans, *Hinde*, sp. nov. Plate XV, figs. 4—4 *b*.

Sponges simple or compound: the simple forms are round or ovate with a short stem; the compound forms consist of three or four small rounded individuals, sessile on a common base, and usually partially amalgamated with each other. Small simple forms are not more than 6 mm. in height by 5 mm. in diameter, whilst the compound specimens are about 14 mm. in breadth by 7 mm. in height. The surface has small subcircular ostia, ·3 mm. in width, and small irregular apertures between the fibres as well; the summits are rounded, the oscule is 2 mm. in width, its rim does not project above the general surface; the cloacal tube is perforated by elongate canal apertures. The excurrent canals are about ·4 mm. in width. The fibre forms a somewhat open mesh; it varies from ·07 mm.

to ·16 mm. in width. In many respects this species is similar to *C. lycoperdioides;* it is, however, a smaller form, and very frequently compound in its mode of growth.

Distribution.—Great Oolite, Hampton Cliffs, near Bath. (Walton Collection, in the Woodwardian Museum, Cambridge.)

30. Corynella punctata, *Hinde*, sp. nov. Plate XVI, figs. 3—3 *c*.

Sponges simple or in small colonies; the simple individuals are subcylindrical, occasionally nodose, the basal portion usually expanded. In the colonies the spongites are short and frequently amalgamated together to near their summits. A well-marked, compact dermal layer encloses the base and sometimes extends half-way to the summit of the sponge. The oscule is circular, and from 1 mm. to 1·25 mm. in width. The surface of the sponge when not covered by the dermal layer is dotted over by ostial apertures of irregular form, sometimes elongate or sub-stellate, bounded by a very delicate spicular mesh (Pl. XVI, fig. 3 *c*). Smaller pore-like interspaces are present as well as ostia. The cloacal tube is of the same width for at least one-half the length of the sponge. The spicular fibres are delicate, ranging from ·07 mm. to ·14 mm. in thickness; the rays of the axial spicules are ·2 mm. in length by ·04 mm. in thickness. This species appears to be rare; of the four specimens examined the largest simple form is 20 mm. in length by 11 mm. in diameter, whilst a colony of three individuals is 14 mm. in height by 16 mm. in breadth. The characters of the surface serve to distinguish this species from the preceding.

Distribution.—Inferior Oolite. Oolite-Marl, *Murchisonæ*-zone at Ravensgate Hill, near Cheltenham, and Birdlip Hill, Gloucester. (Collected by Mr. R. F. Tomes.)

31. Corynella Langtonensis, *Hinde*, sp. nov. Plate XVI, figs. 2, 2 *a*.

Short subcylindrical sponges, growing directly attached to a shell or some other organism. Length from 20 mm. to 28 mm.; thickness from 18 mm. to 27 mm. Summits gently rounded, the oscular aperture about 6 mm. in breadth; from its rim narrow open furrows, about ·5 mm. wide, extend down the sides. The outer surface has numerous irregularly disposed ostia from ·5 mm. to ·75 mm. in breadth. The fibres, as seen in transverse section, are from ·05 mm. to ·18 mm. in thickness; they resemble in structure the fibres of *C. lycoperdioides*, but I have

failed to recognise in them any tuning-fork spicules. In outer form these sponges resemble some of the specimens included under *Corynella Quenstedti*, Zittel = *Spongites astrophorus*, Quenstedt ('Petref. Deutschl.,' vol. v, p. 208, pl. cxxiv, figs. 58, 59), but the fibres in these latter appear to be of a coarser character than in the present species.

Distribution.—Coral Rag. Zone of *Ammonites plicatilis*, Langton Wold, near Malton, Yorkshire. (Collected by Mr. S. Chadwick.)

32. Corynella Chadwicki, *Hinde*, sp. nov. Plate XV, figs. 6, 6 *a*; Plate XVI, figs. 1—1 *d*.

1816. Elongate alcyonite, *Kendall?* Descriptive Catalogue of the Minerals and Fossil Organic Remains of Scarborough, pt. 3, p. 249, pl. iv, fig. 3.
1848. Scyphia cylindrica, *M'Coy* (non *Goldfuss*). Ann. and Mag. Nat. Hist., s. 2, vol. ii, p. 418.
1854. — — *Morris.* Cat. Brit. Foss., 2nd ed., p. 29.

Sponges usually simple, but occasionally bifurcating or in small colonies of two or three individuals growing from a common base and partially attached laterally. The individual spongites are subcylindrical or club-shaped, straight, curved, or contort, occasionally with nodose swellings, sometimes attached to oysters; their bases are flattened or corrugated, the summits are depressed-conical with a circular oscule, the margin of which is either entire or with a few open furrows extending a short distance down the wall. The dermal layer is limited to a few wrinkled bands crossing the lower portion of the sponge obliquely; in some specimens it is not present at all. The cloacal tube extends to nearly the base of the sponge; it is bounded by a very distinct fibrous wall, and relatively wide canals open into it at irregular intervals (Pl. XVI, fig. 1 *a*). The outer surface of the wall is smooth, with a very delicate meshwork of fibres with small irregular pore-like apertures between them, scarcely visible to the naked eye; definite ostia are absent. The fibres of the interior of the wall are more openly disposed than those of the outer surface or those of the cloacal tube; in cross-section they vary from ·05 mm. to ·16 mm. in thickness, whilst those of the cloacal tube are ·25 mm. in breadth. They consist principally of irregular three-rayed spicules, which are so closely intermingled that only single rays can be made out, and these but seldom for their entire length; the longest rays are ·35 mm. by ·05 mm. in thickness. The larger spicules are in the axial portion of the fibres, and they are enclosed sometimes by a marginal layer of sinuous filiform spicules, but whether

these are simple or three-rayed forms is uncertain. These latter spicules predominate in the wall of the cloaca.

There are considerable differences in the size of the sponges; small specimens are only 15 mm. in length by 7 mm. in thickness, whilst the larger reach to 70 mm. in length and from 10 mm. to 20 mm. in thickness. An example of this species from Malton, now in the Woodwardian Museum at Cambridge, was referred by Prof. M'Coy to *Scyphia cylindrica*, Goldfuss, but independently of the presence of a canal system the fibres of the Yorkshire forms are much more delicate than those in the German sponge. According to Mr. Chadwick, to whom I am indebted for the specimens figured, this species is fairly abundant in the beds of Coralline Oolite which cap Langton Wold for a distance of two or three miles. The specimens are usually simple; not infrequently they are partially covered by a small oyster which has grown over the surface, and sometimes other sponges have also attached themselves to it.

Distribution.—Corallian. Coralline Oolite; zone of *Ammonites plicatilis*, Langton Wold, near Malton. Coral Rag, Settrington, Yorkshire (Coll. Mr. S. Chadwick).

33. Corynella cribrata, *Hinde*, sp. nov. Plate XVI, figs. 4—4*f*.

Sponges rarely simple, usually in small colonies of depressed, subcylindrical, conical, or club-shaped individuals, sometimes completely amalgamated together, in other cases merely connected laterally or else quite free and divergent. The basal portion in some specimens has small patches of wrinkled dermal layer, but as a rule the surface is free and the wall fibres uncovered. The summits of the spongites are sometimes inflated, gently rounded, or conical; the oscule either circular or elliptical, from 1 mm. to 3 mm. in breadth, its margin entire or deeply cleft with open furrows; the walls are deeply traversed by canals—those next the surface forming open furrows—which extend longitudinally, obliquely, or even transversely, and seem to anastomose freely. The larger canals are from ·5 mm. to 1 mm. in breadth, and open into the cloacal tube at irregular intervals. These canals vary in number and direction even in individuals of the same colony; for whilst the surface in some specimens is seamed over with them (Pl. XVI, figs. 4, 4 *a*), in others there are but few exposed. As a rule they are more prominent in the smaller specimens. The skeletal fibres are delicate, in transverse section from ·05 mm. to ·18 mm. in thickness. They are mainly composed of irregular three-rayed spicules; one of the rays is usually short and blunt, whilst the other two are more tapering and pointed, ranging from ·16 mm. to ·25 mm. in length. These rays usually overlap one another in

the fibres, and their outlines are very difficult to distinguish in thin sections. Smaller sinuous spicules are present in some of the fibres, but not recognisable in others. In the specimens examined the spicular structure is not well preserved.

There is very great diversity of form and size in the sponges referred to this species, but after careful study of a large series of specimens I feel obliged to unite them together, as in the canal system and in the character of their fibres they are closely similar, and there are numerous transitions between the extremes of the series. The simplest form met with is an ovate specimen, about 10 mm. in length and breadth, growing attached to a fragment of shell. It has a tubular cloaca, and the walls are deeply scored with sinuous furrows (Pl. XVI, fig. 4). In another specimen there are several similar individuals united together into a small colony (fig. 4 *a*), and completely amalgamated; whilst in others the individuals in the colonies may be either partially attached or free from each other except at their bases (figs. 4 *b*—*e*). The largest colony is about 50 mm. in breadth and height, and the spongites from 7 mm. to 9 mm. in diameter. The specimens are for the most part completely weathered out from the matrix, so that the fibres and the canals are shown very distinctly.

Distribution.—Great Oolite. Hampton Cliffs, near Bath. The type-specimens are in the Woodwardian Museum, Cambridge (Walton Collection).

Genus.—HOLCOSPONGIA,[1] *Hinde*, gen. nov.

Sponges simple or growing in colonies. The individual spongites are spherical, hemispherical, subcylindrical, club-shaped, or discoidal; in the compound forms they are sometimes completely amalgamated with each other. The base of the colony and, in some instances, the lateral surfaces of the spongites are usually covered with a rugose dermal layer. Summits rounded or flattened, with a central area, which may or may not be depressed, in which a variable number of excurrent canals open. From the central area a number of open furrows extend over the summit and down the sides of the sponge, and with these furrows canals from the interior communicate.

The skeleton fibres form an open tissue; they consist of fairly large axial three- and in some instances four-rayed spicules enclosed by marginal filiform spicules, probably three-rayed. The dermal layer consists of an agglomeration of three- and perhaps of four-rayed spicules of various dimensions, which are closely felted together.

[1] Ὁλκός, a furrow.

This genus is proposed for a group of Jurassic and Cretaceous sponges which have hitherto been placed in the genus *Stellispongia*, d'Orbigny (' Prodr. de Pal.,' vol. i, 1849, p. 209). In the type of this genus, *S.* (*Cnemidium*) *variabilis*, Münster (' Beitr. zur Petref.,' vol. iv., 1841, p. 30, pl. i, figs. 21—23), from the Triassic strata of St. Cassian, the fibres have been shown by Steinmann (' Neues Jahrbuch,' 1882, vol. ii. p. 180, pl. ix, fig. 2), and I have myself confirmed his observation, to consist of short, simple, blunted, sinuous spicules of an entirely different character from the spicules forming the fibres in the Jurassic sponges, which, on account of their similarity in growth and in canal structures, have been, by Zittel and other authors, placed under *Stellispongia*. It is, therefore, necessary to place these latter forms in a new genus, and to restrict *Stellispongia* to forms with a spicular structure similar to that of the type species.

The genus *Enaulospongia*, Fromentel (' Mém. Soc. Linn. de Normandie,' vol. xi, p. 48), has also been proposed for a sponge which will come under *Holcospongia*, but v. Zittel has pointed out that the characters assigned to it have been based on the erroneous observation that the sponge is without canals, and it is therefore undesirable to adopt it.

34. Holcospongia floriceps, *Phillips*, sp. Plate XVI, figs. 6—6 *c*; Plate XVII, fig. 2.

1829. Spongia floriceps, *Phillips.* Geol. of Yorks, p. 126, pl. iii, fig. 8.
1854. — — *Morris.* Cat. Brit. Foss., p. 30.
1860. — — *Wright.* Quart. Journ. Geol. Soc., vol. xvi, p. 28.
1875. — — *Phillips.* Geol. of Yorks, 3rd edit., p. 235, pl. iii, fig. 8.
1878. — — *Hudleston.* Proc. Geol. Assoc., vol. v, pp. 417, 494.
1878. Peronella floriceps, *Zittel.* Studien, Abth. 3, p. 122.
1883. Stellispongia semicincta et corallina (in part), *Hinde.* Cat. Foss. Sponges, p. 187.

Sponges growing in colonies usually from a blunted conical base. Small colonies consist of from three to five individuals, and they are from 20 mm. to 30 mm. in height and thickness, whilst the individuals in large colonies are numerous, and form masses of considerable size, a specimen now in the York Museum measuring 150 mm. in length, 90 mm. in breadth, and 70 mm. in height. The individuals are obtusely conical or subcylindrical, ranging from 10 mm. to 23 mm. in length, and from 8 mm. to 13 mm. in diameter. The summits are conical, rounded, or truncate, without a depressed area; from the centre well-marked, straight, simple, open furrows, from 1 mm. to 1·5 mm. in

width, extend down the sides. The basal portion of the colony has a rugose dermal layer. The canals traversing the sponge are 1·5 mm. in width ; they are hardly distinguishable, owing to the open arrangement of the skeletal fibres.

The fibres are relatively very coarse and open in their disposition ; they vary between ·15 mm. and ·4 mm. in thickness. The spicules are in such intimate contact that their individual outlines are seldom distinctly shown in thin sections; a single ray of the large axial spicules measures ·46 mm. by ·045 mm. The marginal sinuous spicules are from ·005 mm. to ·01 mm. in thickness.

The distinguishing characters of this species are the truncate-conical form of the individual spongites, the wide well-marked open furrows down their sides, and the coarse character and open structure of the fibres. It grows also in larger masses than any other species of the genus. As a rule the specimens are considerably weathered, so that the surface furrows become obliterated, but it is then recognised by the form of the spongites and the coarseness of the fibres (Pl. XVI, fig. 6 *a*).

Though this species was named and a rude figure of it given by Prof. Phillips in 1829, it does not appear to have been hitherto described. Owing to the imperfect figure, neither generic nor specific characters could be with certainty determined from it, hence Prof. Zittel referred it to the genus *Peronella*, and I had previously placed it with other species of *Stellispongia*. The present description has been based on the type-specimen from the Lower Coral Rag of Hackness, now preserved in the York Museum, and on other specimens from the same locality which have been collected by Mr. S. Chadwick. These specimens are for the most part in a calcareous matrix, which occasionally weathers to a rusty powder, and conspicuously shows the white fibres of the sponge. Sometimes the weathering has acted on the fibres and laid bare their large axial spicules ; in one instance the spicule was distinctly four-rayed. The examples from the Lower Calcareous Grit of Filey are enclosed in a granular siliceo-calcareous matrix, and become partially silicified : they are usually smaller than the specimens from the Lower Coral Rag of Suffield, and rarely show the surface furrows; but the character of the fibres is similar, and in all probability they belong to the same species.

From *Holcospongia* (*Spongites*) *glomerata*, Quenstedt, sp., this species differs in its mode of growth, the more prominent surface furrows, and the coarser fibres of the skeleton.

Distribution.—Corallian. Lower Calcareous Grit at Filey Brigg and Scarborough, also in the Lower Limestones or Lower Coral Rag (*Perarmatus*-zone) at Scarborough, Suffield, Hackness, Yorkshire, and in the Coral Rag at Lyneham, Wiltshire.

35. Holcospongia polita, *Hinde*, sp. nov. Plate XVI, figs. 5—5 *e*.

1883. Stellispongia corallina (in part), *Hinde*. Brit. Foss. Sponges, p. 186, pl. xxxv, fig. 3 *a*.

Sponges simple or compound. The simple forms are subspherical, attached either by a small pedicle or directly by the basal surface; they range from 8 mm. to 15 mm. in diameter. The compound specimens grow in irregular compact masses of from three to five individuals, which are usually amalgamated together. The dermal layer is very slightly developed, and when present is limited to the basal portion. The summits have a slight central depression, from which numerous open shallow furrows about ·75 mm. in width radiate down the sides. The radial canals have a similar width to the surface furrows. The fibres have a very open disposition; they vary from ·05 mm. to ·15 mm. in thickness. The rays of the axial spicules range from ·16 mm. to ·43 mm. in length: the marginal filiform spicules are few comparatively, hence the fibres are much more delicate than in the preceding species.

From *Holcospongia floriceps* this species is distinguished by its smaller size, different form, and the more delicate fibres. It more nearly resembles *H. glomerata*, Quenstedt sp., but the fibres are finer.

This species is abundant in the Lower Coral Rag of Suffield and Hackness, in the same beds with *H. floriceps*. The simple spherical forms are more common than the compound ones. Simple forms also occur rarely in the Great Oolite of Hampton Cliffs, near Bath.

Distribution.—Great Oolite, Hampton Cliffs, near Bath (Woodwardian Museum, Cambridge); Lower Coral Rag, *Perarmatus*-zone at Hackness and Suffield, near Scarborough, Yorkshire (Coll. Mr. J. F. Walker, Mr. S. Chadwick); Coral Rag, Lyneham, Wiltshire.

36. Holcospongia glomerata, *Quenstedt*, sp. Plate XVII, figs. 1—1 *c*.

1858. Spongites glomeratus, *Quenstedt*. Der Jura, p. 695, pl. lxxxiv, figs. 10, 11.

1840–47. Cnemidium stellatum, *Michelin* (non *Goldfuss*). Icon. Zooph., p. 115, pl. xxvi, fig. 8.

1878. Spongites glomeratus, *Quenstedt*. Petref. Deutschl., vol. v, p. 223, pl. cxxv, figs. 26—36, 38, 40—54.

1878. Stellispongia glomerata, *Zittel*. Studien, Abth. 3, p. 130.

1878. — — *Hinde*. Cat. Foss. Sponges, p. 187.

Sponges simple or in small irregular masses of three or more individuals. The basal portion flattened, or hollowed out where they have been attached to the convex surfaces of other bodies; the dermal layer limited to the base. The single specimens are rounded or ovate, from 9 mm. to 18 mm. in diameter. The summits usually without a central depression; from the central portion a few deep open furrows radiate; these are about 1 mm. in width. The skeletal fibres measured in a transverse section are from ·1 mm. to ·25 mm. in thickness. The rays of the axial spicules range up to ·46 mm. in length. The filiform spicules are from ·005 mm. to ·01 mm. in thickness; their length could not be ascertained.

To this species I have referred specimens from the Coral Rag of Malton which appear to agree with some of the forms figured by Quenstedt. They differ from *H. polita*, which comes from a slightly lower horizon, in the coarser character and closer arrangement of the skeletal fibres, and in the greater width of their canals; and they are readily distinguishable from *H. floriceps*. The specimens are usually simple forms, and not infrequently they are attached to the surfaces of *Corynella Chadwicki*. (Pl. XVII, fig. 1.)

Distribution.—Corallian. Coralline Oolite; zone of *A. plicatilis*, Langton Wold, Malton; Coral Rag, Settrington, Yorkshire. (Coll. Mr. S. Chadwick.) Also in the Coral Rag at Nattheim.

37. Holcospongia sulcata, *Hinde*, sp. nov. Plate XVII, figs. 3, 3 *a*—*h*.

Sponges simple, forming small fan-shaped, subcircular or ovate, recurved expansions, either directly attached by a small extension of the margin or by a short conical pedicle. Dermal layer slight, restricted to the base and the surface of attachment. The margins are rounded. On the front or upper surface of the sponge several well-marked, straight or curved, simple or furcate, open grooves radiate from a central area, in which there are one or two oscular apertures, but no definite depression. The grooves are from ·75 mm. to 1 mm. in width; they do not extend as a rule to the margins. The spaces between the grooves are occupied by the fibres and the irregular interspaces between them. (Pl. XVII, figs. 3 *a*, 3 *c*, 3 *e*). On the lower or under surface of the sponge there is a series of grooves or furrows radiating fan-like from the point of attachment to the margin which they traverse, and sometimes reach to the upper surface, but they do not regularly connect with the canals of the upper surface. (Pl. XVII, figs. 3, 3 *b*, 3 *d*). These lower grooves are about ·5 mm. in width; they are marked by elongated apertures about 1 mm. in length, which open into the interior of the wall. In young specimens the grooves appear rather as lines of apertures than continuous open furrows.

The skeleton is an open meshwork of fibres; the main lines running between the grooves are ·3 mm. in thickness in transverse section, and the smaller fibres about ·12 mm. The spicular structure is not very distinctly shown; the rays of the larger axial spicules are about ·33 mm. in length by ·08 mm. in thickness. Sinuous marginal spicules are only slightly developed.

These sponges vary considerably in size; small individuals are not more than 5 or 6 mm. in height and breadth, whilst the largest examined is 22 mm., and the average about 12 mm. in height and breadth. The thickness of the wall-plate does not usually exceed 3·5 mm.

This species is very common in the sponge-bed at Shipton Gorge; it is readily distinguished by its mode of growth and the grooved character of the under surface. The specimens are now all free, but they were originally attached to other bodies, and one of the forms shows on its basal expansion an imprint of the cruciform spicules of a Hexactinellid sponge.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, and in the Cliff-section at Burton Bradstock, near Bridport, Dorset. (Mr. E. A. Walford; G. J. Hinde.)

38. HOLCOSPONGIA CONTORTA, *Hinde*, sp. nov. Plate XVII, figs. 4—4 *d*.

Sponges small, usually simple, but occasionally two individuals are attached at their bases, spherical, hemispherical, or club-shaped, with a flattened or corrugated base. The front surface, and in some forms the summit of the sponge, has from five to six short open grooves or furrows, from ·4 to ·6 mm. in width, radiating star-like from a centre, and bounded by thickened ridges of spicular fibre. These grooves are sometimes contracted to merely oval depressions or oscules, which open into the interior of the wall. The top of the sponge is rounded and sometimes furrowed transversely. The surface opposite to that with the stellate grooves has sometimes slight furrows, or exhibits merely pore-like interspaces between the fibres; not infrequently the entire surface, with the exception of the stellate portion, is covered by a rugose dermal layer, composed of agglomerated three- and four-rayed spicules of various dimensions; the rays of the larger forms, which are very distinctly shown in some parts of the surface, ranging up to ·2 mm. in length, whilst in a small spicule they are not more than ·03 mm. (Pl. XVII, fig. 4 *d*.)

The sponges for the most part are about the size and shape of peas, varying from 3 to 6·5 mm. in diameter. A few exceptional forms are club-shaped, and from 5 to 13 mm. in height. As a rule they are now free, but they appear to have grown by a flattened base on pieces of shell and other organisms. In most of

the specimens the grooves do not radiate from the summit, but from the middle of the front surface. The skeletal fibres are of an open character; they consist mainly of the relatively large axial spicules. The dermal layer has a smooth surface, resembling in appearance the epitheca of corals, but it can be seen to be made up of innumerable three- or perhaps four-rayed spicules of different sizes, irregularly intermingled together, so that the rays overlap each other in all directions.

This species is very abundant in the beds at Shipton Gorge. It is related to *H. sulcata*, but differs in form and size, and in the disposition of the surface furrows.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, Dorset. (Collected by Mr. E. A. Walford.)

39. Holcospongia liasica, *Quenstedt*, sp. Plate XVII, figs. 5—5 *c*.

1878. Spongites liasicus, *Quenstedt*. Petref. Deutschl., vol. v, p. 343, pl. cxxxi, fig. 43.
1883. Myrmecium depressum, *Sollas*. Quart. Journ. Geol. Soc., vol. xxxix, p. 550.

Sponges small, usually simple, though rarely two individuals are attached together; discoidal, with rounded or sharp edges. The under surface may be either flattened, concave, or convex; it is covered by a rugose dermal layer. The upper surface is flattened or convex, with open grooves, simple or furcate, from ·7 to 1 mm. in width, radiating from the central area. The central portion sometimes slightly depressed, with occasional oscules, and in the interspaces between the grooves there are circular canal apertures about ·5 mm. wide. The fibres in transverse section are from ·08 mm. to ·15 mm. in thickness; they consist mainly of robust axial three-rayed spicules. The specimens are from 5 mm. to 9 mm. in width, and from 2·5 mm. to 4·5 mm. in thickness.

In form and surface characters the examples from the Inferior Oolite correspond so closely to the figures given by Quenstedt of a specimen from the Lias near Balingen, that, although unable to compare the minute structure, I think they may be considered to belong to the same species; and, as Prof. Sollas has pointed out, the form described by him from the Great Oolite under the name of *Myrmecium depressum* is equally similar, and may therefore be included as well. As, however, in this specimen there is no tubular cloaca, which according to v. Zittel is one of the essential characters of the genus *Myrmecium*, Goldfuss, it cannot properly be

placed under this genus. The specimens are not uncommon in the Inferior Oolite, but as yet only one has been met with in the Great Oolite.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, near Bridport (Coll. Mr. E. A. Walford). Great Oolite, Hampton Down, near Bath (Coll. Rev. G. F. Whidborne). Also in the Lias near Balingen, Germany (Quenstedt).

40. Holcospongia bella, *Hinde*, sp. nov. Plate XVII, figs. 6—6 *e*.

Sponges small, simple, discoidal, circular in outline, the basal surface either flattened where it has grown on an even surface, or convex with a slight pedicle, and enclosed in a corrugated dermal layer which forms a shallow saucer extending as high as the wall. The upper surface is flattened or slightly raised in the centre, with several well-marked, straight, open grooves, from ·3 mm. to ·5 mm. in width, radiating from the centre or between this and the margin. Between the grooves are slightly raised ridges, on each of which is a row of circular or ovate canal apertures from ·3 mm. to ·5 mm. wide. The skeletal fibres are openly arranged; they vary from ·075 mm. to ·12 mm. in thickness. The fibres show the spicular structure very indistinctly; they are chiefly made up of three-rayed spicules surrounded by smaller filiform spicules.

The specimens are only from 4 mm. to 9 mm. in breadth, and from 1 mm. to 3·5 mm. in thickness. They are now mostly free, but they appear to have grown attached to other organisms; one specimen still remains firmly fixed to a fragment of a Hexactinellid sponge. From *H. liasica* the species is principally distinguished by the regular arrangement of the surface grooves and the canal apertures.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge. (Coll. Mr. E. A. Walford.)

41. Holcospongia mitrata, *Hinde*, sp. nov. Plate XVII, figs. 7—7 *d*.

Sponges small, usually simple, but occasionally two are attached together by the dermal layer, depressed conical to subcylindrical, base flattened, covered by a rugose dermal layer, summit conical or rounded, with from three to five deep open grooves from ·6 mm. to 1 mm. in width, which radiate from the centre and extend down the sides. At the centre in some specimens there is a single oscule, but in

others a low ridge crossing the grooves ; canals from the interior open into the grooves. The surface of the sponge between the grooves has irregularly scattered oval or circular ostia from ·25 mm. to ·45 mm. in width, as well as pore-like interspaces between the fibres. The spicular structure is similar to that of *H. bella.*

The examples of this species are all very small, varying from 4 mm. to 6 mm. in height and from 3·5 mm. to 7 mm. in thickness. The dermal layer is limited to the base of the sponge ; in one specimen it is seen to consist of slender three-rayed spicules : the rays are from ·015 mm. to ·03 mm. in length (Pl. XVII, fig. 7 *d*). The peculiar feature in this species is the manner in which the summit is deeply cleft, so as to give it roughly the appearance of a mitre. The ostia are only seen in the best preserved examples (Pl. XVII, figs. 7, 7 *c*.)

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge (Mr. E. A. Walford), and from the Marl-bed at Bradford Abbas, Dorset (Mr. R. F. Tomes).

Genus.—Myrmecium, *Goldfuss.*

1826–33. Petrefacta Germaniæ, vol. i, p. 18.

Syn.—Cnemidium, *Goldfuss* (in part) ; Spongites, *Quenstedt* (in part) ; Epitheles, *Fromentel* (in part).

Small simple sponges, spherical, hemispherical, or cylindrical, attached by a flattened base or small pedicle ; base, and sometimes the lateral surfaces as well, with a corrugated dermal layer. Summit rounded with a central oscule, from which radiating open furrows are given off. A tubular or funnel-shaped cloaca, into which the radial canals open. Outer surface with pore-like ostia. The skeletal fibres delicate. The type species is *Myrmecium hemisphæricum*, Goldfuss, from the Upper Jura of Thurnau ('Petref. Germ.,' vol. i, p. 18, pl. vi, fig. 12).

42. Myrmecium biretiforme, *Sollas.* Plate XVII, fig. 8.

1883. Myrmecium biretiforme, *Sollas.* Quart. Journ. Geol. Soc., vol. xxxix, p. 550.

The type-specimen referred to this species by Prof. Sollas is small, nearly spherical, attached directly by the base; the summit is depressed with a central circular osculum, from which a few inconspicuous open furrows radiate for a short distance. The outer surface exhibits pore-like irregular apertures between the

fibres, with here and there subcircular ostia. The specimen is 10 mm. in breadth by about 7 mm. in height; it has been sectioned horizontally, but the canal structure is not clearly shown. The width of the oscule and the absence of a basal epitheca in this specimen indicate that it does not belong to *Spongites rotula*, var. *birretiformis*, Quenstedt ('Petref. Deutschl.,' vol. v, p. 234, pl. cxxvi, fig. 6), to which it was referred by Prof. Sollas; but as Quenstedt's species really comes under *Myrmecium hemisphæricum*, Goldfuss, the name proposed by Prof. Sollas for the present form will hold good.

Distribution.—Inferior Oolite. *Parkinsoni*-zone in the Cliff at Burton Bradstock, Dorset. (Coll. Rev. G. F. Whidborne.)

Genus.—Lymnorella, *Lamouroux*,[1]—emend., *Hinde*.

1821. Exposition méthodique des genres de l'ordre des Polypiers, p. 77.

Syn.—Mammillopora, *Bronn*; Lymnoreotheles, *Fromentel*; Placorea, *Pomel*; Inobolia, *Hinde*.

Sponges massive, subglobular, irregularly nodose or branching; the individual spongites either completely amalgamated in a common stock, or projecting as conical, subcylindrical, or rounded forms, with tubular cloaca, giving off from the summit oscule short radiating horizontal furrows. In some instances the cloacal tube is not developed, and the spongites are only indicated by slight depressions here and there on the surface, with short open furrows radiating from them, and occasionally even these are not shown. The mode of growth is usually by a succession of concentric layers which overlap each other.

The base of the sponge may be either concave, or there may be a short stout stem. In both cases the base is covered with a rugose dermal layer, which sometimes extends over the lateral surface of the sponge. The surface which is not covered by the dermal layer either consists entirely of irregular pore-like apertures, bounded by the reticulate fibres, or, in addition to these, circular or stellate ostia. The fibres consist of axial three-rayed spicules (possibly also of four-rayed forms as well), enclosed by an outer layer of what is now almost wholly finely fibrous calcite. In this, fragments of filiform spicules and occasionally tuning-fork spicules are present. In one species, in place of the investing calcite layer, the fibres show definite filiform and three-rayed spicules. The typical species is *Lymnorella mamillosa*, Lamx., from the Calcaire à Polypiers (Forest-marble), near Caen.

[1] The name *Lymnorea* having been previously employed in 1809 by Péron et Lesueur for a genus of hydroid zoophytes, I propose to modify the term by using the diminutive "ella," so that it can be retained for these sponges.

There is considerable variation in the characters of the sponges included in this genus. Some massive forms consist of concentric layers of fibrous skeleton with only occasional traces of canals and a few slight depressions of the surface to mark where oscules may have existed, but no further indications of individual spongites are distinguishable in the common stock; whilst in other stocks, conical spongites, each with a tubular cloaca and an open oscule at its summit, project prominently from the mass. These latter correspond with the type-forms of the genus; for those in which canals and oscules are absent or rarely developed I had proposed the genus *Inobolia* (Cat. Foss. Sponges, Brit. Mus., p. 184), but from the study of a large series of specimens it is evident that this genus cannot be maintained independent of *Lymnorella*, since gradational forms occur between the extremes of the series.

The microscopic characters of the skeleton fibres in the sponges of this genus from the Inferior Oolite of this country, and also in some of the examples from the Calcaire à Polypiers, near Caen, exhibit some peculiar features, which may, however, result from the fossilisation. In thin sections the fibres show three-rayed spicules in the central portion, disposed so that the rays slightly overlap each other; they are white by reflected light, but dark granular by transmitted light (Pl. XVIII, figs. 2 *c*, 3 *c*, 6 *b*). These axial spicules are enclosed by a layer of calcite of a lighter tint, which appears to consist of minute crystalline fibres. This outer layer sometimes contains traces of filiform spicules, but as a rule nothing beyond its crystalline structure is present. It is very distinctly marked off from the infilling calcitic or sedimentary matrix (Pl. XVIII, fig. 3 *b*), showing that it is derived from the original skeleton fibre; and it appears to be probably due to a secondary change which has obliterated the smaller spicules in the marginal portion of the fibres, and left the larger axial spicules in their present opaque granular condition. A somewhat similar condition of the skeleton fibres also occurs in *Peronidella tenuis* (Pl. XIV, fig. 2 *a*). In one species, *Lymnorella micula*, from a different horizon and locality, the fibres retain their normal characters (Pl. XVIII, fig. 5 *b*).

43. Lymnorella mamillosa, *Lamx.* Plate XVIII, figs. 2—2 *c*.

1821. Lymnorea mamillosa, *Lamx.* Exp. méthod., p. 77, pl. lxxix, figs. 2—4.
— — *Blainville.* Man. d'Actinologie, p. 541.
1837. Mammillopora mamillosa, *Bronn.* Leth. geogn., vol. i, p. 236.
1878. Lymnorea mammillaris, *Zittel.* Studien, Abth. iii, p. 128.
1883. — mamillosa, *Hinde.* Cat. Foss. Sponges, p. 184, pl. xxxv, figs. 1, 1 *a*, 1 *b*.

Massive sponges, spherical, hemispherical, or irregular in form, supported on a short stout pedicle, or having the under surface concave and covered with a wrinkled dermal layer. The rounded upper surface may be either nearly even or with slightly projecting conical or rounded eminences. The oscules at their summits are about 1 mm. in width, and short open horizontal furrows, about 5 mm. wide, radiate from their margins. The oscules serve as the apertures of straight tubes or cloaca which extend through the sponge, but they are interrupted at intervals by transverse floors, which mark the different layers of growth (Pl. XVIII, fig. 2 *b*). The general surface is covered by numerous subcircular ostia about ·3 mm. in width, bounded by very fine reticulate fibres. The ostia apparently connect with incurrent canals, which, however, cannot be distinguished in the interior of the sponge from the spaces between the skeleton fibres (Pl. XVIII, fig. 2 *a*). The skeleton fibres are delicate, from ·08 mm. to ·16 in thickness: the three-rayed axial spicules are usually in single series; their rays range up to ·24 mm. in length by ·039 mm. in thickness. Tuning-fork spicules are also present.

The sponges are very variable in size; small specimens are not more than 15 mm. in diameter, whilst large forms reach 63 mm. in length by 40 mm. in breadth and height. As a rule the specimens from the Inferior Oolite are larger than those from the "Calcaire à Polypiers" at Ranville, near Caen. The brief description and poor figures of this species given by Lamouroux leave considerable doubt as to its real characters. This author states that the upper surface is "finement lacuneux et sans pores visibles," which seems to imply that there are no ostia, as in the Inferior Oolite specimen here figured (Pl. XVIII, fig. 2). But in some of the examples from the original locality near Caen, now in the British Museum, which otherwise closely correspond with the description of *L. mamillosa*, there are ostia plainly shown; whilst in others not so well preserved, only the fine apertures between the fibres are visible on the surface, and thus the presence of ostia appears to me to be a character of the species.

Distribution.—Inferior Oolite. Pea-grit series; *Murchisonæ*-zone, Crickley Hill, Ravensgate Hill, near Cheltenham (Mr. R. F. Tomes, Mr. F. Longe); cutting on the Midland and South-West Junction Railway, east of Andoversford (Mr. E. Wethered); Oolite-Marl, Birdlip Hill, near Gloucester (Mr. R. F. Tomes). Also in the Calcaire à Polypiers at Les Moustiers, Ranville, Luc, &c., near Caen, France.

44. Lymnorella inclusa, *Hinde*. Plate XVIII, figs. 3—3 *d*.

1883. Inobolia inclusa, *Hinde*. Cat. Foss. Sponges, p. 185, pl. xxxv, figs. 2, 2 *a*, 2 *b*.

Sponges massive, turbinate, subspherical, or in irregular nodose masses.

Base flattened, concave, or with a short stem, and enclosed by a rugose dermal layer, which sometimes also wraps round the sides as well. The upper surface exhibits minute apertures between the fibres, and occasionally small shallow depressions with one or more circular or elongate apertures connected with shallow canals, which appear to represent the oscules; but in some specimens all traces of oscules and distinctive canals have disappeared, and the circulation must have been carried on in the interspaces of the mesh. Vertical sections show concentric zones of growth, which are also marked by bordering bands of the dermal layer on the outside of the sponge.

The skeleton fibres are of a somewhat coarse character; in some portions they are materially thickened: they range from ·12 to ·24 mm. in thickness. The fibres are in the same crystalline condition as in the previous species; in the thickened portions the axial spicules are more numerous and more closely arranged (Pl. XVIII, fig. 3 *c*): the spicular rays range up to ·3 mm. in length by ·036 mm. in thickness. Slender tuning-fork spicules are likewise present in the fibres; a perfect specimen is ·2 mm. in length (Pl. XVIII, fig. 3 *d*). Very minute three-rayed spicules can also be seen in the dermal layer.

There is great difference in the forms of this species. Some examples are nearly round, others top-shaped, whilst others grow in flattened or irregular nodose masses, consisting of successive layers, overlapping each other either partially or entirely. These range from 20 mm. to 80 mm. in thickness. In many no special canals or oscules can be seen, and the genus *Inobolia* was proposed to include these; but there are specimens in which here and there oscular apertures, connected with short open furrows or canals, are developed, thus showing intermediate stages in the canal system, so that no generic distinction can be made on this ground. The distinction between this species and *L. mamillosa* rests on the absence of ostia, the absence or slight development of the canals, and the coarser fibres. It is probably allied to *L. gigantea*, Michelin ('Icon. Zoophy.,' p. 247, pl. lviii, fig. 7), but the description given of this form is insufficient to allow of a definite comparison.

Distribution.—Inferior Oolite. Pea-grit series, Crickley Hill and Cleve Hill, near Cheltenham. Trigonia-grit, Leckhampton (Mr. R. F. Tomes). The type-specimen is in the British Natural History Museum, South Kensington, and there are also specimens in the museums at Jermyn Street and at York.

45. Lymnorella pygmæa, *Sollas*. Plate XVIII, figs. 4—4 *b*.

1883. Limnorea pygmæa, *Sollas*. Quart. Journ. Geol. Soc., vol. xxxix, p. 549, pl. xxi, figs. 29, 30.

Sponges occasionally simple, but usually in small colonies of teat-like or obtusely conical individuals from 5 to 11 mm. in thickness at their bases. The basal portion either with a short thick peduncle or concave; in both cases it is enclosed in a wrinkled dermal layer, which also sometimes envelops the sides of the spongites, leaving their summits free.

The oscule at the summit of the spongites is circular with entire margin, and from 1 to 2 mm. in width. The skeleton fibres vary from ·08 to ·13 mm. in thickness; they are of the same character and in the same condition of preservation as those of *L. mamillosa*.

Of the specimens referred to this species, two are simple forms about 5 mm. in thickness by 8 mm. in height; the others are small masses, the largest of which is 30 mm. in breadth by 20 mm. in height, and the spongites in it are larger than the specimens described by Prof. Sollas, but they appear to be of the same character. The individuals in the colonies are freer and more distinct than in *L. mamillosa*, and in this respect they approach the forms figured by Michelin as *L. mamillosa* ('Icon. Zoophy.,' p. 247, pl. lvii, figs. 10 *a*, 10 *b*), but which appear to me to be distinct from the types of this species.

Distribution.—Inferior Oolite. Pea-grit series, near Cheltenham (Mr. F. Longe); *Parkinsoni*-zone at Shipton Gorge (Mr. E. A. Walford). Great Oolite, Hampton Down, near Bath (Rev. G. F. Whidborne). I have not seen the type-forms of this species, which have been mislaid.

46. Lymnorella ramosa, *Hinde*, sp. nov. Plate XVIII, figs. 6—6 *b*.

Sponges growing in bushy masses of subcylindrical or compressed solid branches springing from a thickened basal stock. The branches dichotomize, and are either obtusely conical or laterally compressed and rounded at their summits, and they show indications of growth by overlapping layers as in *L. inclusa*. No compact dermal layer is present in the specimens yet known. The branches are from 6 to 14 mm. in thickness; they terminate blindly, and are without oscules or axial canals. The surface of the branches is smooth from the exterior fibres being thickened, so that there are only small apertures between them. Scattered

irregularly over the surface are small rosette-like groups of larger apertures about ·5 mm. each, with in some cases short horizontal open furrows radiating from them. There are only traces of canals extending inwards from these larger apertures. The spicular fibres are from ·1 to ·15 mm. in thickness; in transverse section they appear as a labyrinthine reticulation, with the dark axial three-rayed spicules in single series in the centre of the fibres, and the outer portion crystalline as in the species previously described. Fragments of slender filiform spicules can be distinguished, but no tuning-fork spicules have as yet been met with.

The examples of this species are rare, the largest specimen known, which is now in the Jermyn Street Museum, measures 115 mm. in breadth by 110 mm. in height. The mode of growth readily distinguishes this species; in its surface characters it more nearly resembles *L. inclusa*, but the fibres are closer and more delicate.

Distribution.—Inferior Oolite. Pea-grit series, at Crickley Hill and Andoversford, near Cheltenham. (Coll. Mr. R. F. Tomes; Mr. E. Wethered.)

47. Lymnorella micula, *Hinde*. Plate XVIII, figs. 5—5 *d*.

1884. Inobolia micula, *Hinde*. Quart. Journ. Geol. Soc., vol. xl, p. 779, pl. xxxv, figs. 1, 1 *a*—*d*.

Sponges small, occurring as rounded or irregular nodose and somewhat lobate masses, sometimes showing indications of overlapping zones of growth with marginal bands of dermal layer. The base is either rounded or concave, and enclosed in a dermal layer. Some of the specimens show a surface only of smooth fibres with irregular interspaces, and may perhaps be considered as simple sponges; in some of the lobate forms there are faint indications of centres from which some obscurely-marked, open furrows radiate, but there are no oscules or tubular canals. The skeletal fibres are coarse generally, and range from ·14 to ·37 mm. in thickness. They consist of axial three- and perhaps four-rayed spicules, and a definite marginal border of slender filiform spicules, and also of tuning-fork spicules (Pl. XVIII, fig. 5 *b*). The dermal layer consists of three-rayed spicules of various dimensions. The rays of the larger spicules reach a length of ·3 mm. by ·05 mm. in thickness. Some of the tuning-fork spicules are very perfectly shown; in the one figured (Pl. XVIII, fig. 5 *c*) the straight-paired, parallel rays are as long as the unpaired ray. The spicule is ·25 mm. in length.

The sponges range from small—perhaps incomplete—forms not more than 2·5 mm. in thickness to rounded masses 32 mm. in diameter. In its mode of

growth this species resembles *L. inclusa*, but it is much smaller, the fibres are coarser, and there is a great difference in the present structure of the skeleton fibres; this difference, however, probably arises from the fact that in *L. inclusa* the fossilisation has obliterated the smaller spicules and produced the peculiar radiate crystallisation which now characterises them, whereas in this species they retain their normal features.

Distribution.—Great Oolite. Hampton Cliffs, near Bath (Walton Coll., Woodwardian Museum, Cambridge). Also from the well-boring at Richmond, Surrey, at a depth of 1205 feet beneath the surface.

Genus.—Oculospongia, *Fromentel.*

1859. Introduction à l'étude des Éponges fossiles, Mém. de la Soc. Linnéenne de Normandie, vol. xi, No. 2, p. 37.

Syn.—Manon, *Goldfuss* (in part); Oculispongia, Tremospongia, *Roemer* (in part); Sphecidion, *Pomel.*

Sponges rounded, nodose, or club-shaped, massive; the summits with a few scattered circular oscules from which tubular canals or cloaca extend into the body of the sponge; the surface between the oscules with irregular pore-like apertures between the fibres. The base, and frequently the sides of the sponge as well, covered with a dermal layer. The fibres of the skeleton consist of three-rayed spicules in the central portions, with sinuous filiform spicules near the exterior. The type-species is *Oculospongia Neocomiensis*, Fromentel ('Introduction,' p. 37, pl. ii, fig. 8), from the Lower Neocomian at Germigney.

48. Oculospongia minuta, *Hinde.* Plate XIX, figs. 7—7 *b.*

1884. Oculospongia minuta, *Hinde.* Quart. Journ. Geol. Soc., vol. xl, p. 782, pl. xxxv, figs. 5, 5 *a.*

Sponges small, rounded, ovate, or nodose, from 5 to 10 mm. in diameter. Base flattened or concave, with wrinkled dermal layer which sometimes envelops the sides of the sponge, leaving only the upper surface free. The convex upper surface has irregularly scattered, subcircular, oscular apertures, from ·5 to ·75 mm. in width, and between these are the smaller irregular apertures, from ·1 to ·4 mm. in width, of the interstices of the fibres. The skeleton fibres are from ·1 to

·25 mm. in thickness; the rays of the larger three-rayed spicules reach to ·17 mm. in length by ·035 mm. in thickness.

The small sponges included in this species have their oscules and cloacal tubes less prominently developed than in the more typical species of the genus, but they agree better with the characters of *Oculospongia* than with those of any other genus.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, Dorset. (Coll. Mr. E. A. Walford.) Also in the Jurassic beds in the well-boring at Richmond, Surrey, at 1205 feet beneath the surface.

Genus.—Eudea, *Lamouroux.*

1821. Exposition méthodique des genres de l'ordre des Polypiers, p. 46.

Syn.—Verrucospongia, *d'Orbigny* (in part); Epeudea, Ependea, Stegendea, *Fromentel;* Spongites, Orispongia, *Quenstedt;* Solenolmia, Verrucospongia, Elasmeudea, *Pomel.*

Sponges simple or rarely branching; subcylindrical, club-shaped, conical or rounded, with a tubular cloacal cavity opening at the summit and reaching nearly to the base of the sponge. The surface of the sponge, with the exception in some cases of the summit portion, is covered with a thickened dermal layer in which at irregular intervals there are circular or ovate apertures, usually with prominent margins, which open directly into the interspaces between the sponge-fibres. No special canal system beyond that in the interspaces of the fibres. The spicular structure of the fibres very indistinctly shown; three-rayed spicules are present in the central portions of the fibre, and in some instances simple rod-like spicules as well.

The type-species is *Eudea clavata*, Lamx., from the Terrain à Polypiers, near Caen ('Exposition méthodique,' p. 46, pl. lxxiv, figs. 1—4).

49. Eudea Walfordi, *Hinde*, sp. nov. Plate XIX, figs. 1—1 *c*.

Sponges small, simple, subglobular to subcylindrical, attached by a flattened or concave base, the summits truncate or gently rounded, with a central or subcentral oscule about 1 mm. wide with slightly projecting margin. The outer surface usually entirely covered with the dermal layer, but sometimes the summit portion is free and exhibits the fibres. The apertures in the dermal layer are

circular to oval in form, ·6 to 1 mm. in width, with slightly elevated margins; they are irregularly placed, and vary in number in different specimens. In some specimens the skeletal fibres are nearly even with the apertures.

The skeletal fibres are stout; they range from ·08 mm. to ·17 mm. in thickness; the surface layer, and that round the cloacal tube, is specially thickened, and reaches ·25 mm. in transverse section. The spicular structure is very obscurely shown; there are traces of three-rayed spicules and of rod-like forms, which may be portions of tuning-fork spicules, but they are too fragmentary and indefinite to be measured or figured. The specimens range from 3·5 mm. to 6·5 mm. in height, and from 3 mm. to 4·5 mm. in diameter. They are fairly common.

In form this species is nearest allied to *Eudea perforata*, Quenstedt, sp. ('Der Jura,' p. 698, pl. lxxxiv, figs. 26, 27; and 'Petref. Deutschl.,' vol. v, p. 192, pl. cxxiv, figs. 22—28), but it is much smaller, and the skeletal fibres are more delicate. I have named it after Mr. E. A. Walford, F.G.S., who discovered this and the numerous other forms of Calcisponges herein described from Shipton Gorge.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, near Bridport. (Coll. Mr. E. A. Walford.)

50. Eudea pisum, *Quenstedt*, sp. Plate XIX, figs. 2—2 *b*.

1878. Obispongia pisum, *Quenstedt*. Petref. Deutschl., vol. v, p. 196, pl. cxxiv, figs. 35, 36.
1878. Eudea pisum, *Zittel*. Studien, Abth. 3, p. 117.

Sponges small, simple, conical or subspherical, sometimes with constrictions of growth, attached either by a narrow or an expanded base, summits conical, with oscule about ·7 mm. wide. Outer surface nearly entirely covered with dermal layer, in which there are circular apertures, about ·5 mm. wide, at the end of short tubular extensions. The specimens range from 5 mm. to 9 mm. in height, and from 3 mm. to 5 mm. in width. The fibres appear to be finer than in *E. Walfordi*, but owing to scarcity of material I have not been able to make sections. This species differs further from *E. Walfordi* in form, in the smaller size of the apertures, and in their tubular extensions.

Distribution.—Inferior Oolite. *Parkinsoni*-zone at Shipton Gorge, Dorset. (Coll. Mr. E. A. Walford.) Also from the Upper or White Jura at Böllert, Balingen, Germany (Quenstedt).

Genus.—Elasmostoma, *Fromentel.*

1859. Introduction à l'étude des Éponges fossiles, Mémoires de la Soc. Linnéennede Normandie, vol. xi, p. 42.

Syn.—Tragos, Manon, Spongia, *Auct.* (in part); Porostoma, Chenendroscyphia, *Fromentel* (in part); Chenendopora, Cupulospongia, *Roemer* (in part); Trachypenia, Coniatopenia, *Pomel.*

Sponges with laminated walls, flattened or convolute; occasionally cup- or funnel-shaped. One surface of the wall is covered with a smooth, compact, or minutely perforate dermal layer, in which are large circular or irregular oscular apertures, which open into the interspaces between the skeletal fibres. The opposite surface is without a dermal layer, and the fibres are uncovered. Skeletal fibres stout, forming an openly reticulate mesh, in which canals, as a rule, are not definitely shown. They consist of large axial three-rayed spicules, enclosed by sinuous filiform spicules; tuning-fork spicules are likewise present in some species, the same as in *Holcospongia*.

The type-species is *E. acutimargo*, Roem., sp. ('Verst. d. Nordd. Oolithgeb. Nachtrag,' p. 10, pl. xvii, fig. 26), from the Neocomian at Berklingen, Brunswick.

51. Elasmostoma palmatum, *Hinde*, sp. nov. Plate XVII, figs. 9—9 *c*; Plate XVIII, figs. 1, 1 *a*.

1854. Spongia helvelloides, *Morris* (*non* Lamx.). Cat. Brit. Foss., 2nd ed., p. 30.

Sponges growing in the form of fan- or ear-shaped plates, variously curved and thickened, attached directly by the margin or by a short blunt pedicle. The walls are from 3·5 mm. to 7 mm. in thickness. The dermal layer covering one surface is compact, with numerous subcircular or irregular oscules from 2 mm. to 3 mm. in width, and usually with elevated margins (Pl. XVIII, fig. 1). Sometimes the oscules are nearly close together, at others about their own diameters apart; they open directly into the interspaces of the fibres beneath. The opposite or non-oscular surface of the sponge has only the irregular spaces between the fibres, which are unusually stout on the exterior (Pl. XVII, fig. 9 *a*). The margins of the wall are rounded.

The skeletal fibres are stout, reticulate, from ·1 mm. to ·5 mm. in thickness; the rays of the axial three-rayed spicules range up to ·26 mm. in length by ·06 mm. in thickness; the smaller sinuous spicules border the fibres, and are interlaced

between the larger spicules (Pl. XVII, fig. 9 *c*). Tuning-fork spicules are present, but it is seldom that they can be recognised in sections. The dermal layer consists of three-rayed spicules closely felted together. Some of these, weathered out on the surface, are as large as the spicules in the fibres (Pl. XVIII, fig. 1 *a*).

The examples of this species vary considerably in form and size; small specimens are 10 mm. in height by 13 mm. in breadth, whilst a large one measures 40 mm. in height by 35 mm. in breadth. The smaller forms are usually fan-shaped; sometimes the walls are flattened, plate-like, with slightly incurved margins; in other instances they are variously contorted, and become thickened and lobed. In many of the specimens the dermal layer is no longer present, and it is very seldom intact even when it has been preserved, and is usually concealed by a growth of small oysters and Serpulæ. The dermal layer appears to be quite distinct from the skeletal fibres, which it covers.

This species is distinguished from the Neocomian species *E. acutimargo*, Roemer, by its thicker walls, and the oscular apertures are much more closely arranged.

Distribution.—Great Oolite. Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge (Walton Collection). Forest Marble at Winsley, near Bath (Mr. E. A. Walford).

Genus.—Diaplectia, *Hinde.*

1883. Cat. Foss. Sponges Brit. Mus., p. 193.

Syn.—Spongia, *Lamx.* (in part); Pharetrospongia, *Zittel* (in part).

Sponges with laminated walls, either cup-, fan-, or platter-shaped. A dermal layer is not developed, and there is no canal system apart from the interspaces of the fibres. The fibres are in some instances disposed longitudinally, in others generally reticulate. The spicular structure consists of axial three-rayed spicules, marginal filiform spicules, and tuning-fork spicules, the same as in *Elasmostoma*, Fromontel.

This genus differs from *Elasmostoma* in the absence of a dermal layer with oscules on one surface. This structure is very liable to disappear in the fossilisation, and Prof. v. Zittel has suggested the probability that sponges similar to those herein included, in which it is now absent, may have been originally covered with this layer. There are, however, numerous well-preserved sponges, such as, for example, those of *Spongia helvelloides*, Lamx., from near Caen, in which not a trace of dermal layer has yet been noticed, and it seems desirable to include such provisionally in a separate genus.

52. Diaplectia auricula, *Hinde.* Plate XIX, figs. 3, 3 *a.*

1883. Diaplectia auricula, *Hinde.* Cat. Foss. Sponges, p. 193, pl. xxxvi, figs. 4, 4 *a.*

Fan- or ear-shaped sponges; the walls from 5 to 10 mm. in thickness with rounded margins. The exterior surface shows a reticular arrangement of the fibres with irregular interspaces. The fibres are very robust, from ·2 to ·4 mm. in thickness; the axial spicules are closely arranged, the marginal spicules have sinuous rays which are dovetailed into each other; occasionally a third ray can be seen in these spicules. Tuning-fork spicules are also present. The only specimen is 30 mm. in height and 50 mm. in breadth.

Distribution.—Inferior Oolite. Pea-grit, near Cheltenham (British Natural History Museum).

53. Diaplectia infundibulum, *Hinde*, sp. nov. Plate XIX, figs. 4, 4 *a.*

Funnel-shaped sponges, walls from 2 to 4 mm. in thickness, the margin rounded. Both the inner and outer surface smooth, the fibres generally reticulate, from ·1 to ·25 mm. in thickness. The interspaces between the fibres irregular, with occasional suboval larger spaces nearly ·5 mm. in width.

Only a single specimen is known, which is 20 mm. in height and 27 mm. in breadth at the summit. In general form it resembles some of the specimens of *Diaplectia helvelloides*, Lamx., sp. ('Exp. méthod.,' p. 87, pl. lxxxiv, figs. 1—3), but the fibres are distinctly finer, and they have not the longitudinal arrangement as in this latter species.

Distribution.—Great Oolite. Bradford, Wiltshire (Woodwardian Museum, Cambridge).

Genus.—Blastinia, *Zittel.*

1878. Studien über fossile Spongien, Abhandl. der k. bayer. Akademie der Wiss., Cl. ii, Bd. xiii, Abth. 3, p. 132.

Syn.—Achilleum, *Goldfuss* (in part); Actinospongia, Pterosmila, *Pomel;* Astrospongia, *Etallon* (in part); Tetrasmila, *Fromentel* (in part).

Sponges simple or compound, subspherical, hemispherical, obtusely conical,

alate, or irregular in form, sessile or with a short pedicle, the base flattened or concave, and with a dermal layer, which in some cases extends over the lower part of the sponge. The upper portion of the sponge is seamed by a series of deeply impressed furrows, which radiate from the summit, and between them are ridges, lobes, or wing-like flanges, which are occasionally laterally corrugated. The sponge is built up of reticulate fibres, which are very thick in the central portions, but slender and open near the exterior. The fibres consist of medium-sized three-rayed spicules, sometimes in a single series or but slightly overlapping each other, but more closely grouped together in the central portion of the flanges or ridges. There is no cloacal tube nor definite canals.

The peculiar form and the absence of a cloacal tube and special canal system readily distinguish this genus. The type-species, *Blastinia* (*Achilleum*) *costata*, Goldfuss, sp., is from the Middle Jura of Streitberg, Würtemberg (' Petref. Germ.,' vol. i, p. 94, pl. xxxiv, fig. 7).

54. Blastinia costata, *Goldfuss*, sp. Plate XIX, figs. 5—5 *c*.

1826—33. Achilleum costatum, *Goldfuss*. Petref. Germ., vol. i, p. 94, pl. xxxiv, fig. 7.
1878. Blastinia costata, *Zittel*. Studien, Abth. 3, p. 132.
1884. — cristata, *Hinde*. Quart. Journ. Geol. Soc., vol. xl, p. 781, pl. xxxv, figs. 3—3 *b*.

Sponges small, simple, hemispherical, depressed-conical or oval in outline, base flattened, or concave when growing on a convex object, with a rugose dermal layer, which in some instances covers the lower portion of the sponge. From the summit a variable number, generally from five to nine, deep depressions extend to near the base, and between these is a corresponding number of rounded ridges. The surface of the ridges merely shows small irregular apertures between the fibres. As seen in a transverse section of the sponge the fibres follow a linear arrangement, radiating from the central area. They are, as a rule, delicate, about ·03 mm. in thickness, but near the ridged portions they become very considerably thickened, and reach ·32 mm. in width. They consist of apparently subequal three-rayed spicules, the rays of which are from ·12 mm. to ·17 mm. in length, and about ·05 mm. in thickness.

The examples of this species are all of small dimensions, ranging from 3 mm. to 7·5 mm. in height, and from 3 to 8 mm. in diameter, and thus they are somewhat smaller than Goldfuss's figured type, which is 10 mm. in height. In the character and number of the ridges our specimens correspond with the type-species, and I do not now see sufficient grounds to regard them as distinct, though from a misunder-

standing as to the real size of the form figured by Goldfuss I previously placed the specimen from the Richmond well-boring as a separate species. I consider, however, that the forms placed in this species by Quenstedt ('Der Jura,' p. 695, pl. lxxxiv, fig. 8; and 'Petref. Deutschl.,' vol. v, p. 221, pl. cxxv, figs. 19—22) are distinct from Goldfuss's type, and probably belong to another species, if not to another genus. The specimen also which I named *Blastinia pygmæa* ('Quart. Journ. Geol. Soc.,' vol. xl, p. 781, pl. xxxv, figs. 4, 4 *a*) seems to me now to be possibly a young form of this or of some other species, and the name should be dropped.

Distribution.—Inferior Oolite, Oolite-Marl, Ravensgate Hill, near Cheltenham. Collected by Mr. R. F. Tomes. Also from the Jurassic beds met with in the well-boring at Richmond, Surrey, at a depth of 1205 feet. Middle beds of the Jura-Kalk at Streitberg (Goldfuss).

55. Blastinia aspera, *Hinde*, sp. nov. Plate XIX, figs. 6—6 *d*.

Sponges simple or compound; the simple forms are conical, pyramidal, hemispherical, and occasionally irregular; the base is flattened or concave according to the surface to which it has been attached; the dermal layer is limited to the base. The ridges or crests are usually sharp-edged, with lateral corrugations; they are separated by wide open depressions, or they stand out as flange-like lobes, from three to six in number, which usually unite at the summit, though in some cases there is a furrow between them above. The specimens vary considerably in form and size; the smallest individual is only 9 mm. in height by 8 mm. in diameter, whilst a compound specimen, in which several conical forms grow on a common base, is 20 mm. in height, 24 mm. in length, and 17 mm. in diameter.

In transverse section the skeleton has the same general arrangement as in *B. costata*,—that is, there are simple delicate fibres, mainly of three-rayed spicules, in a single series near the exterior, whilst in the central portion of the ridges the fibres are unusually thick (Pl. XIX, fig. 6 *c*), ranging from ·4 mm. to 1 mm. in width, though built up of the same kind of spicules as in the more delicate fibres. The rays of the spicules reach up to ·21 mm. in length by ·05 mm. in thickness.

By its larger size, mode of growth, and disposition of the fibres, this species may be distinguished from *B. costata*, Goldfuss, to which it is nearest allied. The specimens do not appear to be uncommon; those which I have seen were all obtained by Mr. S. Chadwick, of Malton.

Distribution.—Coral Rag, *Perarmatus*-zone, at Suffield, near Scarborough, Yorkshire. (Coll. Mr. S. Chadwick.)

Family.—LEUCONES (*Bowerbank*), *Haeckel.*

1872. Die Kalkschwämme, vol. ii, p. 113.

Calcisponges, whose usually thick walls are traversed irregularly by sinuous, branching, often anastomosing canals. The spicules are irregularly distributed in the body of the sponge.

Owing to the loose indefinite arrangement of the skeletal spicules in the sponges of this family they are, as might be supposed, extremely rare as fossils, and the forms from the Middle Lias, described below, are the only representatives known up to the present time in the fossil condition, if we except a few detached spicules occurring in the Upper Chalk and in Pliocene strata.

The chief difference between the Leucones and the Pharetrones, to which all the other Calcisponges herein described belong, consists in the fact that the spicules in this latter family are arranged so as to form solid anastomosing fibres, whereas in the Leucones they are loosely scattered in the soft tissues.

Dunikowski has, however, maintained ('Palæontographica,' vol. xxix, 1883, p. 34) that the fibrous character of the Pharetrones-skeleton is a secondary structure due to the fossilisation, and he has consequently considered the group as only a sub-family of Leucones. The character of the spicules and of the canal system in these families is admittedly very similar, but the markedly distinct fibrous arrangement of the skeleton, which appears to me to be original and not secondary in its nature, justifies, in my opinion, the family distinction assigned by v. Zittel to the Pharetrones as distinct from Leucones.

Genus.—Leucandra, *Haeckel.*

1872. Die Kalkschwämme, vol. ii, p. 170.

Calcisponges with branching canals, in which the skeleton consists of three- and four-rayed spicules as well as simple rod-like forms.

56. Leucandra Walfordi, *Hinde.* Pl. XIX, figs. 8—8 *x*.

1889. Leucandra Walfordi, *Hinde.* Ann. and Mag. Nat. Hist., s. 6, vol. iv, p. 352, pl. xvii, figs. 1—9.

Sponges small, club-shaped, subcylindrical or compressed, slightly contracted at the base, which is attached to grains of sand or fragments of other organisms.

The specimens usually occur single, but in some instances two or three individuals are attached together at their bases. They range from 2 mm. to 3·5 mm. in height and from ·6 mm. to 1 mm. in thickness. The outer surface is slightly hispid with obliquely projecting cylindrical or rod-like spicules; the summits are obtusely conical or truncate, without distinctive neck or spicular collar. The cloacal tube extends to nearly the base of the sponge; it opens by a circular or, in the compressed forms, elliptical aperture, from ·2 to ·5 mm. in width (Pl. XIX, fig. 8 *d*). The inner or cloacal surface of the wall is apparently smooth, and, as far as can be seen, without a special spicular layer. The walls of the sponge are about ·2 mm. in thickness; they are composed of cylindrical or fusiform acerates or rods and three- or four-rayed spicules of various dimensions, which for the most part are indiscriminately intermingled together.

The greater number of the simple spicules are nearly straight subcylindrical rods, with styliform slightly inflected ends; they are usually broken; the longest fragments measure ·43 mm. in length by ·005 mm. to ·01 mm. in thickness. Others are straight or slightly curved, fusiform or nearly cylindrical, with acute ends. They range from ·09 to ·29 mm. in length, and from ·0035 mm. to ·007 mm. in thickness (Pl. XIX, figs. 8 *e*—8 *i*). Some of these simple spicules are disposed nearly parallel with or somewhat obliquely to the outer surface, from which their distal ends slightly project. Of the three-rayed spicules (Pl. XIX, figs. 8 *k*—8 *q*) some are regular,—that is, with the rays of equal length; the rays in others appear, however, to be often unequal, but as one or more are usually broken it is not easy to determine how far they may have been similar originally. The rays are smooth, straight, or rarely with a slight curvature, and they gradually taper to an acute point. Sagittate three-rayed forms appear to be absent, but a four-rayed sagittate has been noticed (Pl. XIX, fig. 8 *r*). The spicules vary considerably in size; the rays of a small form are not more than ·03 mm. in length by ·004 mm. in thickness, whilst those of a large spicule measure ·26 mm. in length and ·01 mm. in thickness near the centre. In the four-rayed spicules (Pl. XIX, figs. 8 *r*—8 *u*) the additional apical ray is usually shorter than the three facial rays; in some instances it is more robust, and somewhat abruptly pointed. In cross-section some of the spicular rays are distinctly elliptical.

Very little of the character of the canal system can be ascertained in the wall of this species; there are here and there minute circular apertures visible on the outer surface (Pl. XIX, fig. 8 *a*) which may be apertures of incurrent canals, and traces of winding anastomosing canals are exposed in fractured portions of the wall, whilst indications of the larger excurrent canals are visible on the inner or cloacal surface.

The sponges occur detached and free in a decayed rusty rock, mingled with

sand, oolitic grains, and broken-up fragments of crinoids or other Echinoderms. In outer form some are as perfect as recent specimens, and their spicular structure has been preserved almost unaltered and uninjured in spite of the fact that their constituent spicules are exceedingly slender, fragile, and minute, and that they are only loosely and irregularly intermingled together. The spicules are now somewhat more brittle than those of existing Calcisponges, their surfaces are smooth and without trace of erosion, and they have the same general appearances under the microscope and in polarised light as recent Calcisponge spicules, though they are hardly so lustrous.

Distribution.—Marlstone of the Middle Lias; zone of *Ammonites spinatus*, at King's Sutton, Northamptonshire, associated with Foraminifera, Corals, Mollusca, and Polyzoa. These sponges were discovered by Mr. E. A. Walford, after whom the species is named.

APPENDIX.

TABLE I.—*List of British Jurassic Sponges, zoologically arranged.*

Name of Genus and Species.	Reference to Page and Plate.	Lias.	Inferior Oolite.	Great Oolite.	Oxford Clay.	Corallian.	Kimmeridge.	Portland.	Purbeck.
SILICISPONGIÆ.									
HEXACTINELLIDÆ.									
1. Tremadictyon sparsum, *Hinde*, sp. nov.	P. 195, Pl. X, figs. 1, 1 *a*		×						
2. — incertum, *Hinde*, sp. nov.	P. 196, Pl. X, figs. 2, 4		×						
3. Calathiscus variolatus, *Sollas*	P. 197, Pl. XI, figs. 1, 1 *a*—1 *c*		×						
4. Craticularia clathrata, *Goldfuss*, sp.	P. 198, Pl. XI, fig. 5		×						
5. — foliata, *Quenstedt*, sp.	P. 199, Pl. X, figs. 6, 6 *a*, 6 *b*		×						
6. Verrucocœlia Whidborni, *Sollas*, sp.	P. 200, Pl. XI, figs. 2, 2 *a*		×						
7. — elegans, *Sollas*, sp.	P. 201, Pl. XI, figs. 3, 3 *a*		×						
8. — major, *Sollas*, sp.	P. 201, Pl. XI, fig. 4		×						
9. Stauroderma explanatum, *Hinde*, sp. nov.	P. 202, Pl. X, figs. 5, 5 *a*		×						
LITHISTIDÆ.									
10. Platychonia Brodiei, *Sollas*	P. 204, Pl. XII, figs. 4, 4 *a*	×							
11. — elegans, *Sollas*	P. 204, Pl. XII, figs. 2, 2 *a*, 2 *b*		×						
12. — tenuis, *Hinde*, sp. nov.	P. 205, Pl. XII, figs. 6, 6 *a*		×						
13. — affinis, *Hinde*, sp. nov.	P. 205, Pl. XII, figs. 5, 5 *a*		×						
14. Leiodorella contorta, *Hinde*, sp. nov.	P. 206, Pl. XII, figs. 1, 1 *a*		×						
15. Melonella ovata, *Sollas*, sp.	P. 207, Pl. XIII, figs. 1, 1 *a*—1 *c*		×						
TETRACTINELLIDÆ.									
16. Pachastrella antiqua, *Moore*, sp.	P. 208, Pl. XIII, figs. 3, 4	×						×	
17. Geodites, sp. (*a*)	P. 209, Pl. XIII, fig. 5							×	
18. — sp. (*b*)	P. 210, Pl. XIII, fig. 5 *a*		×						
19. Rhaxella perforata, *Hinde*	P. 210, Pl. XIII, figs. 7, 7 *a*—7 *f*					×			
MONACTINELLIDÆ.									
20. Spongilla Purbeckensis, *Young*	P. 212, Pl. XIII, figs. 6, 6 *a*								×
CALCISPONGIÆ.									
Family PHARETRONES.									
21. Peronidella pistilliformis, *Lamx.*, sp.	P. 213, Pl. XIV, figs. 1, 1 *a*—1 *d*			×					
22. — tenuis, *Hinde*	P. 215, Pl. XIV, figs. 2, 2 *a*		×						
23. — Metabronnii, *Sollas*	P. 215, Pl. XIV, figs. 4, 4 *a*—4 *f*		×						
24. — Waltoni, *Hinde*, sp. nov.	P. 216, Pl. XIV, figs. 3, 3 *a*—3 *c*			×					
25. — recta, *Hinde*, sp. nov.	P. 217, Pl. XV, figs. 1 *a*—1 *c*					×			
26. — nana, *Hinde*	P. 218, Pl. XV, figs. 2, 2 *a*—2 *g*		×	×					
27. Eusiphonella prolifera, *Hinde*, sp. nov.	P. 219, Pl. XV, figs. 5, 5 *a*			×					
28. Corynella lycoperdioides, *Lamx.*, sp.	P. 220, Pl. XV, figs. 3, 3 *a*—3 *h*			×					
29. — elegans, *Hinde*, sp. nov.	P. 221, Pl. XV, figs. 4, 4 *a*, 4 *b*			×					
30. — punctata, *Hinde*, sp. nov.	P. 222, Pl. XVI, figs. 3, 3 *a*—3 *c*		×						
31. — Langtonensis, *Hinde*, sp. nov.	P. 222, Pl. XVI, figs. 2, 2 *a*					×			

Name of Genus and Species.	Reference to Page and Plate.	Lias.	Inferior Oolite.	Great Oolite.	Oxford Clay.	Corallian.	Kimmeridge.	Portland.	Purbeck.
CALCISPONGIÆ (*cont.*).									
32. Corynella Chadwicki, *Hinde*, sp. nov......	P. 223 { Pl. XV, figs. 6, 6 *a* ...... Pl. XVI, figs. 1, 1 *a*—1 *d* }		...	...	...	×			
33. — cribrata, *Hinde*, sp. nov.........	P. 224, Pl. XVI, figs. 4, 4 *a*—4 *f*	...	...	×					
34. Holcospongia floriceps, *Phillips*, sp.	P. 226 { Pl. XVI, figs. 6, 6 *a*—6 *c* Pl. XVII, fig. 2 .... }		...	...	...	×			
35. — polita, *Hinde*, sp. nov.......	P. 228, Pl. XVI, figs. 5, 5 *a*—5 *e*	...	...	×	...	×			
36. — glomerata, *Quenstedt*, sp....	P. 228, Pl. XVII, figs. 1, 1 *a*—1 *c*	...	...	...	...	×			
37. — sulcata, *Hinde*, sp. nov. ...	P. 229, Pl. XVII, figs. 3, 3 *a*—3 *h*	...	×						
38. — contorta, *Hinde*, sp. nov....	P. 230, Pl. XVII, figs. 4, 4 *a*—4 *d*	...	×						
39. — liasica, *Quenstedt*, sp.	P. 231, Pl. XVII. figs. 5, 5 *a*—5 *c*	...	×						
40. — bella, *Hinde*, sp. nov.	P. 232, Pl. XVII, figs. 6, 6 *a*—6 *e*	...	×						
41. — mitrata, *Hinde*, sp. nov. ...	P. 232, Pl. XVII, figs. 7, 7 *a*—7 *d*	...	×						
42. Myrmecium biretiforme, *Sollas*	P. 233, Pl. XVII, fig. 8............	...	×						
43. Lymnorella mamillosa, *Lamx.*...............	P. 235, Pl. XVIII, figs. 2, 2 *a*—2 *c*	...	×						
44. — inclusa, *Hinde*	P. 236, Pl. XVIII, figs. 3, 3 *a*—3 *d*	...	×						
45. — pygmæa, *Sollas*..................	P. 238, Pl. XVIII, figs. 4, 4 *a*, 4 *b*	...	×	×					
46. — ramosa, *Hinde*, sp. nov.	P. 238, Pl. XVIII, figs. 6, 6 *a*, 6 *b*	...	×						
47. — micula, *Hinde*	P. 239, Pl. XVIII, figs. 5, 5 *a*—5 *d*	...	...	×					
48. Oculospongia minuta, *Hinde*	P. 240, Pl. XIX, figs. 7, 7 *a*, 7 *b*	...	×	×					
49. Eudea Walfordi, *Hinde*, sp. nov...........	P. 241, Pl. XIX, figs. 1, 1 *a*—1 *c*	...	×						
50. — pisum, *Quenstedt*, sp.................	P. 242, Pl. XIX, figs. 2, 2 *a*, 2 *b*	...	×						
51. Elasmostoma palmatum, *Hinde*, sp. nov....	P. 243 { Pl. XVII, figs. 9, 9 *a*—9 *c* Pl. XVIII, figs. 1, 1 *a*... }		...	×					
52. Diaplectia auricula, *Hinde*	P. 245, Pl. XIX, figs. 3, 3 *a*......	...	×						
53. — infundibulum, *Hinde*, sp. nov.	P. 245, Pl. XIX, figs. 4, 4 *a*......	...	...	×					
54. Blastinia costata, *Goldfuss*, sp...............	P. 246, Pl. XIX, figs. 5, 5 *a*—5 *c*	...	×	×					
55. — aspera, *Hinde*, sp. nov...........	P. 247, Pl. XIX, figs. 6, 6 *a*—6 *d*	...	...	...	...	×			
Family Leucones.									
56. Leucandra Walfordi, *Hinde*	P. 248, Pl. XIX, figs. 8, 8 *a*—8 *x*	×							

Table II.—*List of Fossil Sponges in the Different Divisions of Jurassic Strata.*

Lias.

Pachastrella antiqua, *Moore*, sp.	Lower Lias.
Platychonia Brodiei, *Sollas.*	Mid Lias.
Leucandra Walfordi, *Hinde.*	,,

Inferior Oolite.

Tremadictyon sparsum, *Hinde.*	*Parkinsoni-zone.*
— incertum, *Hinde.*	,,
Calathiscus variolatus, *Sollas.*	,,
Craticularia clathrata, *Goldfuss.*	,,
— foliata, *Quenstedt.*	,,
Verrucocœlia Whidborni, *Sollas.*	,,
— elegans, *Sollas.*	,,
— major, *Sollas.*	,,
Stauroderma explanatum, *Hinde.*	,,
Platychonia elegans, *Sollas.*	,,
— tenuis, *Hinde.*	,,
— affinis, *Hinde.*	,,
Leiodorella contorta, *Hinde.*	,,
Melonella ovata, *Sollas.*	*Humphresianus-zone.*
Geodites, sp (*b*).	*Parkinsoni-zone.*
Peronidella tenuis, *Hinde.*	*Murchisonæ-zone.*
— Metabronnii, *Sollas.*	*Parkinsoni-zone.*
Peronidella nana, *Hinde.*	*Parkinsoni-zone.*
Corynella punctata, *Hinde.*	*Murchisonæ-zone.*
Holcospongia sulcata, *Hinde.*	*Parkinsoni-zone.*
— contorta, *Hinde.*	,,
— liasica, *Quenstedt.*	,,
— bella, *Hinde.*	,,
— mitrata, *Hinde.*	,,
Myrmecium biretiforme, *Sollas.*	,,
Lymnorella mamillosa, *Lamx.*	*Murchisonæ-zone.*
— inclusa, *Hinde.*	,,
— pygmæa, *Sollas.*	*Parkinsoni-zone.*
— ramosa, *Hinde.*	*Murchisonæ-zone.*
Oculospongia minuta, *Hinde.*	*Parkinsoni-zone.*
Eudea Walfordi, *Hinde.*	,,
— pisum, *Quenstedt.*	,,
Diaplectia auricula, *Hinde.*	*Murchisonæ-zone.*
Blastinia costata, *Goldfuss.*	,,

Great Oolite.

Peronidella pistilliformis, *Lamx.*
— Waltoni, *Hinde.*
— nana, *Hinde.*
Eusiphonella prolifera, *Hinde.*
Corynella lycoperdioides, *Lamx.*
— elegans, *Hinde.*
— cribrata, *Hinde.*
Holcospongia polita, *Hinde.*
Lymnorella pygmæa, *Sollas.*
— micula, *Hinde.*
Oculospongia minuta, *Hinde.*
Elasmostoma palmatum, *Hinde.*
Diaplectia infundibulum, *Hinde.*
Blastinia costata, *Goldfuss.*

Corallian.

Rhaxella perforata, *Hinde.*
Peronidella recta, *Hinde.*
Corynella Langtonensis, *Hinde.*
— Chadwicki, *Hinde.*
Holcospongia floriceps, *Phillips.*
— polita, *Hinde.*
— glomerata, *Quenstedt.*
Blastinia aspera, *Hinde.*

Portland Beds.

Pachastrella antiqua, *Moore.*
Geodites, sp. (*a*).

Purbeck Beds.

Spongilla Purbeckensis, *Young.*

It is somewhat difficult to institute a comparison between the Jurassic sponges in our British area and those from the Palæozoic rocks previously described, since so many of these latter are only known from the isolated spicules, whereas in the majority of the Jurassic sponges, the form and the connected skeletal structures are sufficiently preserved to allow their systematic position to be satisfactorily determined. There can hardly be any doubt, however, that the Tetractinellid genera, *Geodites* and *Pachastrella*, are common to both divisions; but apart from these the Jurassic sponges appear to be generically distinct from the Palæozoic forms. The structure of the Jurassic sponges is, moreover, of the same character as that of their successors in the Cretaceous rocks and in existing seas; there is, further, a marked absence of those peculiar types of spicular structure common in the older rocks.

As regards the Siliceous sponges, the number of genera and species in the British area falls far short of those present in the various zones of the Jurassic "Spongitenkalk" of South Germany and Switzerland; but, on the other hand, the Calcisponges are probably more numerous and varied in the British Jurassic rocks than in those of the Continent.

INDEX TO VOLUME I.

Note.—The plate-numbers are given in large Roman numerals, and the numbers of the figures in small Roman numerals. The numerals in **black type** indicate the page on which the diagnosis occurs.

ERRATA.

P. 100, second line from bottom, *integrated*, should read *disintegrated*.

P. 228, second line from top, *Brit.*, should read *Cat*.

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PLATE I.

Figs. 1, 1 *a*.—Protospongia fenestrata, *Salter*.

Fig. 1.—A fragment of the spicular-mesh of the Sponge-wall, embedded in hard black slate. Natural size. From Menevian strata, St. David's, South Wales. Drawn from the type example of the species, now in the British Museum (Natural History).

Fig. 1 *a*.—A portion of the spicular-mesh of the same specimen, magnified five diameters. The original regular arrangement has been partly broken up, and owing to the cleavage of the rock the angles of the spicules are distorted.

Figs. 2, 2 *a*.—Protospongia Hicksi, *Hinde*, sp. nov.

Fig. 2.—The compressed Sponge-wall, traces of which can be seen covering the surface of a slab of dark shale. Natural size. From Menevian strata, Porth-y-Rhaw, St. David's, South Wales. Drawn from the type specimen, in the Woodwardian Museum, Cambridge.

Fig. 2 *a*.—Portion of the spicular-mesh of the same specimen in an imperfect condition. Magnified five diameters.

Figs. 3, 3 *a*, 3 *b*.—Hyalostelia fasciculus, *M'Coy*, sp.

Fig. 3.—Portion of the anchoring-rope of the Sponge, showing the parallel disposition of the component spicules. Natural size. Probably from Llandeilo Rocks. Original in British Museum (Natural History).

Fig. 3 *a*.—Transverse section of the same specimen, enlarged ten diameters.

Fig. 3 *b*.—Portion of the rope, enlarged ten diameters, showing the annular or spiral frills on the spicules.

Figs. 4, 4 *a*.—Hyalostelia Smithii, *Young and Young*, sp.

Fig. 4.—Portion of the rock, showing the size and the distribution of the anchoring-spicules in transverse section. Magnified five diameters. From Ordovician shale at Knockgeiran, near Girvan, Ayrshire. The original specimen in the collection of the author.

Fig. 4 *a*.—A longitudinal section of the rock, showing the spicules, which have been cut through obliquely. The transverse bands in them arise from the replacement of the silica by a mineral of a different aspect. Magnified five diameters.

Figs. 5, 5 *a*—5 *f*.—Hyalostelia gracilis, *Hinde*, sp. nov.

Figs. 5, 5 *a*—*c*.—Hexactinellid spicules, with the normal number of rays, though mostly imperfect.

Figs. 5 *d*, *e*.—Cruciform spicules, rays all unequal. In 5 *e* they are spinous.

Fig. 5 *f*.—Microspined cylindrical rods, probably belonging to the anchoring spicules of the Sponge. All magnified forty diameters. From decayed Wenlock limestones, Craven Arms, Shropshire. The original specimens in the collection of John Smith, Esq., Kilwinning, Ayrshire.

Figs. 6, 6 *a*—6 *d*.—Atractosella siluriensis, *Hinde*, sp. nov.

Detached fusiform spicules, referred to this species. The specimens are siliceous; 6 *a*, *b*, are partially encrusted with matrix. Magnified forty diameters. From Wenlock limestones, Craven Arms, Shropshire. The original specimens in the collection of John Smith, Esq., Kilwinning.

Figs. 7, 7 *a*—7 *d*.—Astræospongia patina, *F. Roemer*.

Detached spicules of this species, the rays in all cases imperfect. In Figs. 7 *a*, *b*, *c*, only the six horizontal rays are present, in Fig. 7 one ray of the vertical axis is developed, whilst 7 *d* represents an abnormal form in which only half the number of the horizontal rays is developed. Magnified forty diameters. From Wenlock shales at Wren's Nest, Dudley, and at Benthall Edge, Shropshire. The original specimens in the collection of John Smith, Esq., Kilwinning.

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PALÆOZOIC SPONGES

PLATE II.

Figs. 1, 1 *a*, 1 *b*.—Ischadites Kœnigii, *Murchison.*

Fig. 1.—The cast of a fairly complete specimen, showing the summit aperture and the vertical furrows formed by the transverse rays of the spicules. Natural size. From Wenlock Limestone at Wren's Nest, Dudley. The original specimen in the Woodwardian Museum at Cambridge.

Fig. 1 *a*.—Compressed cast of a specimen, in which the spicular summit-plates have disappeared, and the transverse rays beneath are shown. Natural size. From Wenlock Limestone, Dudley. The original specimen in the British Museum (Natural History).

Fig. 1 *b*.—Casts of two entire specimens, and fragments of four others, partially embedded in a slab of hard calcareous shale. The lozenge-shaped depressions are the casts of the spicular summit-plates, and the casts of the transverse rays of the spicules can be seen in most of the depressions. Natural size. From Lower Ludlow Rocks at Ludlow. Drawn from the type of the species, now in the Museum of the Geological Society, Burlington House.

Figs. 2, 2 *a*.—Ischadites Lindstrœmi, *Hinde.*

Fig. 2.—Cast of the basal portion of a specimen, partially embedded in matrix, showing the concave base, the lozenge-shaped depressions of the spicular summit-plates, and the radial and concentric lines formed by the transverse rays of the spicules. Natural size. Wenlock beds at Malvern. The original specimen in the Natural History Museum, Oxford (Grindrod Collection).

Fig. 2 *a*.—Cast of the upper portion of an individual, showing the central aperture and impressions of the summit-plates. Natural size. Wenlock beds at Malvern. Original in the Natural History Museum, Oxford (Grindrod Collection).

Fig. 3.—Receptaculites Neptuni? *Defrance.*

Cast of a portion of the under or outer surface of a specimen on a slab of limestone. The margins of the spicular summit-plates are distinctly crenulated. Natural size. Wenlock Limestone, Malvern. The original specimen in the Natural History Museum, Oxford (Grindrod Collection).

Figs. 4, 4 *a*—4 *c*.—Dictyophyton Danbyi, *M'Coy*, sp.

Figs. 4, 4 *a*.—Casts of two specimens, partially embedded in an arenaceous matrix, showing in high relief the vertical and transverse ridges formed by the spicules. Natural size. From Upper Ludlow beds at Benson Knot and Brigsteer, Kendal. The original specimens in the Woodwardian Museum at Cambridge.

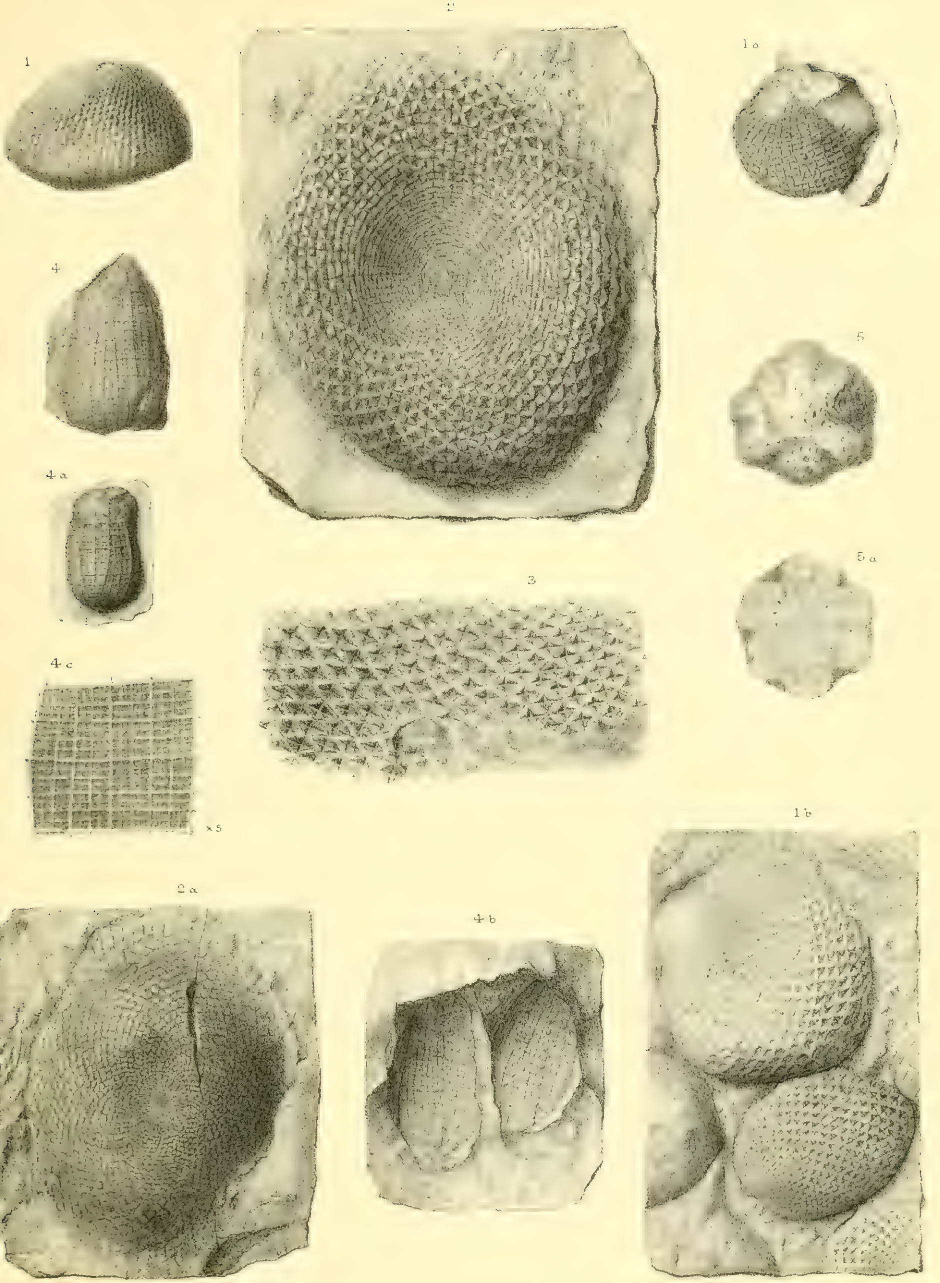
Fig. 4 *b*.—Casts of two specimens, in an arenaceous matrix, showing the impression of the spicular structures in bas-relief. Natural size. From Lower Ludlow strata at Underbarrow, Westmoreland. The original specimen in the Museum of the Geological Society, Burlington House.

Fig. 4 *c*.—Portion of the surface of 4 *a*, enlarged five diameters, showing the larger and subordinate quadrate areas of the spicular mesh.

Figs. 5, 5 *a*.—Astylospongia incisolobata, *F. Rœmer.*

Fig. 5.—The specimen seen from above, showing the canal-apertures. Natural size. From Caradoc strata at Haverfordwest, South Wales. The original specimen in the Museum of the Geological Survey, Jermyn Street.

Fig. 5 *a*.—A transverse section of the same specimen, showing traces of the canals. The spicular structure is not preserved.



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PALÆOZOIC SPONGES.

PLATE III.

Figs. 1, 1 *a*, 1 *b*.—Plectoderma scitulum, *Hinde*.

Fig. 1.—A portion of the wall of the Sponge, showing the disposition of the spicular-mesh, for the most part represented merely by negative casts. Natural size. From Upper Ludlow strata in the Pentland Hills. The original specimen in the Collection of the Geological Survey of Scotland, Edinburgh.

Fig. 1 *a*.—A portion of the same specimen, showing the fasciculate arrangement of the vertical rays, and the single disposition of the transverse rays of the mesh-spicules. The silica of the spicules is, in part, preserved. Magnified five diameters.

Fig. 1 *b*.—Another portion of the specimen, similarly enlarged, showing casts of cruciform-spicules. In the larger spicule, to the right of the figure, a fifth ray is indicated.

Figs. 2, 2 *a*, 2 *b*.—Phormosella ovata, *Hinde*, nov. sp.

Fig. 2.—Impressions of nine individuals on a slab of arenaceous rock. Natural size. From Ludlow strata at Mocktree, Shropshire. The original specimen in the Museum of the Geological Survey, Jermyn Street.

Fig. 2 *a*.—A single Sponge, magnified two diameters.

Fig. 2 *b*.—A portion of the surface of a specimen showing the disposition of the cruciform-spicules in the Sponge-wall. Enlarged five diameters.

Figs. 3, 3 *a*—*f*.—Amphispongia oblonga, *Salter*.

Fig. 3.—Casts of nine individuals, closely associated together on a slab of arenaceous rock. Natural size. From Upper Ludlow strata at Wetherlawlinn, Pentland Hills, near Edinburgh. The original specimen in the British Museum (Natural History).

Fig. 3 *a*.—A single Sponge with indications of an axial hollow in its lower portion. Natural size.

Fig. 3 *b*.—A portion of the upper surface of a specimen, showing the regular arrangement of the spicules, now represented by negative casts. Enlarged ten diameters.

Figs. 3 *c*, 3 *d*.—Casts of two detached spicules, forming the upper portion of the Sponge. Enlarged twenty diameters.

Figs. 3 *e*, 3 *f*.—Casts of two detached conical spicules, forming the basal portion of the Sponge. Enlarged ten diameters.

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PALÆOZOIC SPONGES.

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PLATE IV.

Fig. 1.—Receptaculites Neptuni, *Defrance.*

A fragmentary specimen showing the inner or upper surface, in places worn down so that only transverse sections of the vertical rays of the spicules are exposed. Natural size. From Devonian strata at Mudstone Bay, Devonshire. The original specimen in the collection of A. Champernowne, Esq., F.G.S.

Figs. 2, 2 *a*—2 *d*.—Sphærospongia tessellata, *Phillips*, sp.

Fig. 2.—An imperfect specimen; showing very distinctly the hexagonal summit-plates of the spicules. Natural size. From Middle Devonian strata at Newton Bushell, Devonshire. The original specimen in the Museum of the Geological Survey, Jermyn Street.

Fig. 2 *a*.—A vase-shaped specimen, the upper portion concealed by the matrix. Natural size. The original specimen in the British Museum (Natural History).

Fig. 2 *b*.—An imperfect specimen, showing the inner surface of the Sponge-wall, and the vertical and concentric ridges formed by the transverse spicular rays. Natural size. The original specimen in the British Museum (Natural History).

Fig. 2 *c*.—A fragment of a specimen showing the spicular structure of the inner surface of the wall. Enlarged two diameters. The original specimen in the British Museum.

Fig. 2 *d*.—Another fragment showing the transverse rays of the individual spicules in connection with their respective summit-plates. Enlarged two diameters. The original specimen in the Museum of the Geological Survey, Jermyn Street.

This specimen, as well as those mentioned above, are from Middle Devonian strata, at Newton Bushell, Devonshire.

Fig. 3.—Geodites simplex, *Hinde*, sp. nov.

A group of detached, siliceous spicules of various sizes. Enlarged twenty diameters. From decayed chert in Carboniferous Limestone at Ben Bulben, Sligo, Ireland. The original specimens in the collection of Joseph Wright, Esq., F.G.S., Belfast.

Fig. 4.—Reniera scitula, *Hinde*, sp. nov.

Detached cylindrical spicules. Enlarged twenty diameters. Also from Carboniferous Limestone at Ben Bulben, Sligo.

Figs. 5 *a*—5 *f*.—Reniera Carteri, *Hinde.*

Detached spicules, showing variations in size and form. Enlarged twenty diameters. From the Upper Limestone series of the Lower Carboniferous, at Dalry, Ayrshire. The original specimens in the collection of Dr. R. J. Hunter, Carluke.

Fig. 6.—Axinella vetusta, *Hinde*, sp. nov.

Detached acuate spicule. Enlarged twenty diameters. From the same horizon and locality as the preceding species. The original specimen in the collection of Mr. John Smith, of Kilwinning.

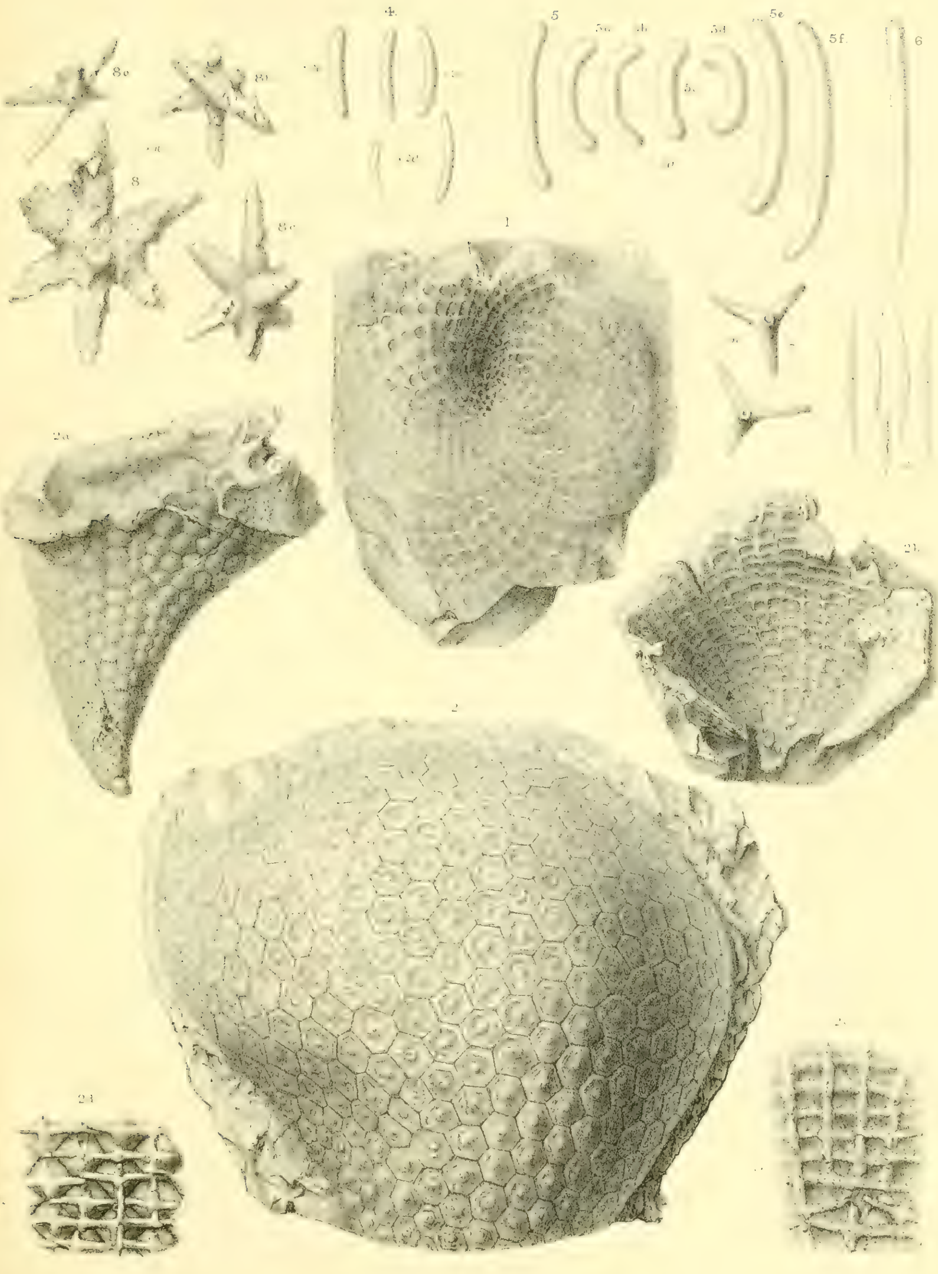
Fig. 7.—Pachastrella humilis, *Hinde*, sp. nov.

Detached four-rayed spicules. Enlarged forty diameters. From Carboniferous Limestone at Ben Bulben, Sligo.

Figs. 8, 8 *a*—8 *c*.—Astræospongia devoniensis, *Hinde*, sp. nov.

Several detached spicules, the rays imperfect and partly encrusted by matrix. Enlarged ten diameters. From Middle Devonian strata at Newton Abbot, Devonshire. The original specimens in the collection of Mr. John Smith, Kilwinning.

PLATE IV



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PALÆOZOIC SPONGES.

PLATE V.

Figs. 1, 1 *a*, 1 *b*.—HAPLISTION ARMSTRONGI, *Young and Young.*

Fig. 1.—The type-specimen, showing its upper surface. Enlarged two diameters. Lower Carboniferous. From the upper part of the Lower Limestone series at Cunningham Baidland, Ayrshire. The original specimen in the collection of Dr. R. J. Hunter, Carluke.

Fig. 1 *a*.—A fragment of another specimen, showing the partially weathered-out spicules composing the fibres. Enlarged fifteen diameters. From Law Quarry, Dalry, Ayrshire.

Fig. 1 *b*.—A portion of the same, still further enlarged to forty diameters, showing the arrangement of the spicules.

Figs. 2, 2 *a*.—HAPLISTION VERMICULATUM, *Carter*, sp.

Fig. 2.—The type-specimen, showing the upper surface. Enlarged two diameters. Lower Carboniferous, upper part of the Lower Limestone series, at Cunningham Baidland, Ayrshire. The original specimen in the collection of Mr. James Thomson, F.G.S., Glasgow.

Fig. 2 *a*.—A portion of the same specimen, showing the conical extensions of the fibres and the partially weathered-out spicules. Enlarged twenty diameters.

Figs. 3, 3 *a*—3 *d*.—GEODITES ANTIQUUS, *Hinde.*

Fig. 3.—Detached acerate spicules referred to this species. Enlarged twenty diameters. Lower Carboniferous. Upper Limestone series, Glencart, Dalry.

Figs. 3 *a*—*d*.—Detached bifid and trifid spicules. The shafts of all are imperfect. Enlarged twenty diameters. From the same horizon and locality as the preceding. The original specimens in the collections of Mr. J. Smith and of Dr. R. J. Hunter.

Figs. 4, 4 *a*—4 *g*.—GEODITES DEFORMIS, *Hinde*, sp. nov.

Figs. 4, 4 *a*—4 *c*.—Detached fusiform and sub-cylindrical spicules referred to this species. Enlarged ten diameters. From the Lower Carboniferous, upper part of the Lower Limestone series at Law Quarry, Dalry.

Figs. 4 *d*—4 *g*.—Detached bifid and trifid spicules of this species. The shafts in all are imperfect. Enlarged ten diameters. From the same beds as the preceding. The original specimens in the collections of Mr. John Smith and Mr. James Bennie.

Figs. 5, 5 *a*—5 *c*.—PACHASTRELLA VETUSTA, *Hinde.*

Detached four- and five-rayed spicules, referred to this species. Enlarged twenty diameters. From Lower Carboniferous, upper part of Lower Limestone series, Law Quarry, Dalry. The original specimens in the British Museum (Natural History) and in the collection of Mr. J. Smith.

Figs. 6, 6 *a*—6 *f*.—CNEMIDIASTRUM PRISCUM, *Hinde*, sp. nov.

Detached spicules of various forms, referred to this species. Enlarged forty diameters. From Carboniferous Limestone at Ben Bulben, Sligo, Ireland. The original specimens in the collections of Mr. J. Wright and of Mr. H. J. Carter, F.R.S.

Figs. 7, 7 *a*—7 *c*.—DORYDERMA DALRYENSE, *Hinde.*

Detached spicules of various forms, referred to this species. Enlarged forty diameters. From the Lower Carboniferous, upper part of Lower Limestone series at Law Quarry, Dalry, Ayrshire. The original specimens in the British Museum and in the collection of Mr. J. Smith, Kilwinning.

Figs. 8, 8 *a*—8 *f*.—HINDIA PUMILA, *Hinde*, sp. nov.

Detached spicules of various forms, referred to this species. Enlarged forty diameters. From Carboniferous Limestone at Ben Bulben, Sligo. The original specimens in the collection of Mr. Joseph Wright, F.G.S.

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PALÆOZOIC SPONGES

PLATE VI.

Figs. 1, 1 *a*—1 *l*, 2, 2 *a*—2 *k*.—HYALOSTELIA SMITHII, *Young and Young*, sp.

Fig. 1.—A fragment of the dermal layer of the Sponge, showing the larger spicules in their natural position with respect to each other. Enlarged ten diameters. Lower Carboniferous, upper part of the Lower Limestone series at Cunningham Baidland, Dalry, Ayrshire. The original specimen in the collection of Mr. John Smith, Kilwinning.

Figs. 1 *a*—1 *l*.—Detached spicules of the skeleton and of the dermal layer. All enlarged to the same scale of ten diameters. 1 *a* represents a spicule of the dermal layer in which the sixth or distal ray is reduced to a small knob. In figs. 1 *f*, 1 *g*, five of the rays are similarly reduced. From the same locality and horizon, and in the same collection as the preceding.

Fig. 2.—A fragment of the anchoring-rope of the Sponge, composed of elongated spicular-rods. Partially embedded in a slab of limestone. Natural size. From Carboniferous Limestone (Yoredale series), near Richmond, Yorkshire. The original specimen in the British Museum (Natural History).

Fig. 2 *a*.—A transverse section of a portion of the same specimen, showing the spicular-rods in section. The clear circular spaces in the centre of each indicate the axial canals. Enlarged ten diameters.

Fig. 2 *b*.—A portion of a longitudinal section of the same specimen, showing three of the spicular-rods with the axial canal in the centre of each. The intervening dark bands consist of the calcareous matrix. Enlarged ten diameters.

Fig. 2 *c*.—A fragment of a detached spicular-rod, showing the central axial canal and parallel lines of growth. Enlarged ten diameters. From Law Quarry, Dalry. The original specimen in the collection of Mr. John Smith.

Figs. 2 *d*—2 *k*.—Detached fragments of the anchoring spicular-rods showing the four recurved rays at their distal extremities. All enlarged ten diameters. Lower Carboniferous at Low Baidland and Cunningham Baidland, Dalry, Ayrshire. The original specimens in the collection of Mr. J. Smith.

Figs. 3, 3 *a*—3 *g*.—HYALOSTELIA PARALLELA, *M'Coy*, sp.

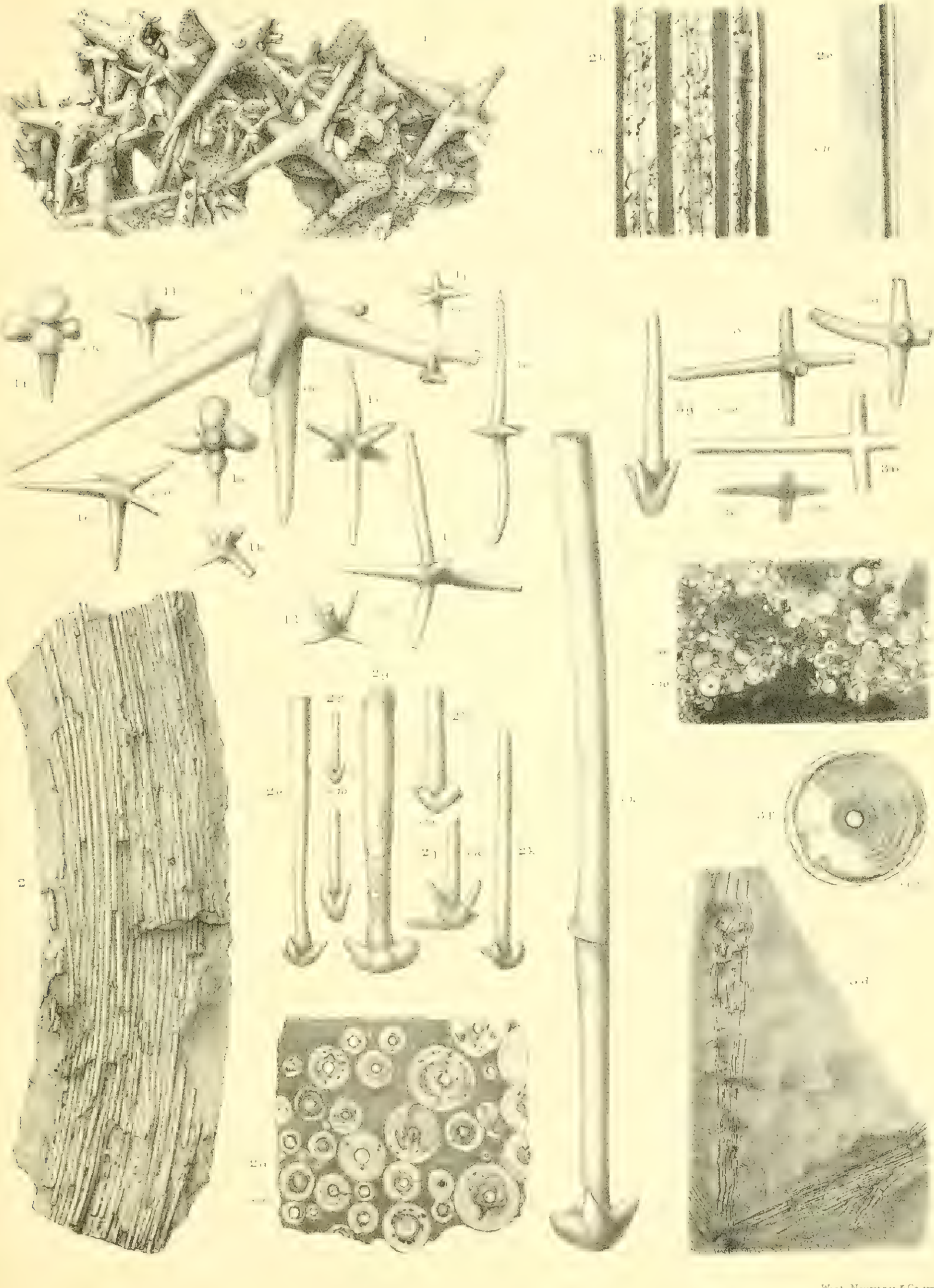
Figs. 3, 3 *a*—3 *c*.—Detached five-rayed spicules probably belonging to the dermal layer of the Sponge. Enlarged twenty diameters. From Carboniferous Limestone at Ben Bulben, Sligo, Ireland. The original specimens in the collection of Mr. J. Wright.

Fig. 3 *d*.—Fragmentary bundles of spicular-rods forming the anchoring-rope of the Sponge. Exposed on the surface of a slab of dark limestone. Natural size. From Carboniferous Limestone, Clogher, Tyrone, Ireland. Drawn from part of the type specimen of *Serpula socialis*, Portl., now in the Museum of the Geological Survey, Jermyn Street.

Fig. 3 *e*.—A transverse section of one of the anchoring-ropes, showing great variation in the thickness of the component spicules. Enlarged ten diameters. From Carboniferous Limestone at Clitheroe, Lancashire. The original specimen in the British Museum.

Fig. 3 *f*.—Transverse section of one of the spicular-rods in 3 *e*, showing the central axial canal and concentric circles of growth. Magnified sixty diameters.

Fig. 3 *g*.—The distal extremity of one of the spicular-rods, showing the four recurved rays. Magnified twenty diameters. From Ben Bulben, Sligo. The original specimen in the collection of Mr. J. Wright, Belfast.



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PALÆOZOIC SPONGES.

PLATE VII.

Figs. 1, 1 *a*—1 *g*.—THOLIASTERELLA GRACILIS, *Hinde*, sp. nov.

Figs. 1, 1 *a*, 1 *b*.—Fragments of the dermal layer of the Sponge, showing the inner surface, and the mode in which the horizontal rays of the spicules are interlaced, and partially fused together. The vertical rays of the spicules are directed towards the interior of the Sponge. Enlarged ten diameters. From the Lower Carboniferous, upper part of the Lower Limestone series at Law Quarry, Dalry, Ayrshire. The original specimens in the collection of Mr. John Smith, Kilwinning.

Figs. 1 *c*—1 *g*.—Detached spicules referred to the same species. In 1 *c*, 1 *d*, the inner or under surface of the spicule is shown, and in 1 *e*, 1 *f*, 1 *g*, the outer or upper surfaces; whilst in 1 *h*, the spicule, showing the vertical ray, is seen in profile. All enlarged ten diameters. From the same horizon and locality as the preceding.

Figs. 2, 2 *a*—2 *f*.—THOLIASTERELLA YOUNGI, *Hinde*.

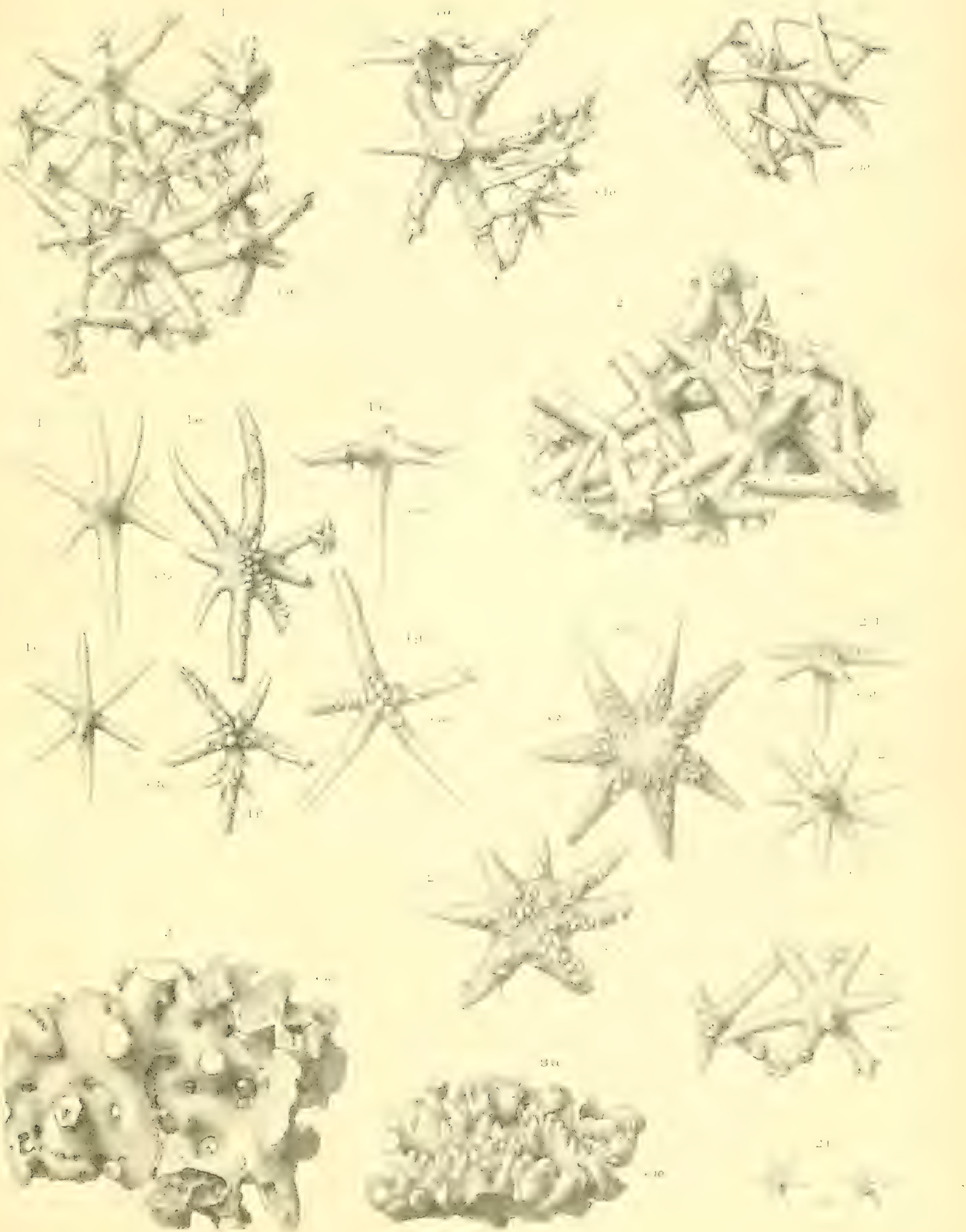
Figs. 2, 2 *e*.—Fragments of the dermal layer of the Sponge, showing the inner or under surface and the interlacing of the spicules. Enlarged ten diameters. From the same horizon and locality as the preceding.

Figs. 2 *a*—2 *d*, 2 *f*.—Detached spicules referred to the same species. In 2 *a*, 2 *f*, the under surface of the spicules is shown; in 2 *b*, 2 *c*, the upper surface; whilst 2 *d* is seen in profile. The original specimens in the collection of Mr. John Smith.

Figs. 3, 3 *a*.—THOLIASTERELLA COMPACTA, *Hinde*, sp. nov.

Fragments of the dermal layer of the Sponge. Fig. 3 shows the inner surface, and the mode in which the spicular rays are completely fused together. The vertical or entering rays of the spicules are broken off, and only their truncated bases remain. Fig. 3 *a* shows the upper or outer surface of another fragment. Enlarged ten diameters. From the Lower Carboniferous at Law Quarry, Dalry, Ayrshire.

The original specimens in the collection of Mr. James Bennie.



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PALÆOZOIC SPONGES.

PLATE VIII.

Figs. 1, 1 *a*—1 *h*.—SPIRACTINELLA WRIGHTII, *Carter*, sp.

Fig. 1.—A large skeletal-spicule in which the distal ray and the four transverse rays are bifurcate.

Figs. 1 *a*, 1 *b*.—Smaller skeletal-spicules with simple rays.

Fig. 1 *c*.—A skeletal-spicule in which all the rays are furcate.

Figs. 1 *d*, 1 *e*.—Small six-rayed spicules in which each of the rays are divided at their extremities.

Figs. 1 *f*, 1 *g*, 1 *h*.—Stellate spicules resulting from the bifurcation of six-rayed spicules.

The specimens are all drawn to the same scale of forty diameters. From decayed chert in Carboniferous Limestone at Ben Bulben, Sligo, Ireland. The original specimens in the collection of Mr. J. Wright, F.G.S., of Belfast, with the exception of 1 *d*, 1 *e*, which belong to Mr. H. J. Carter, F.R.S.

Figs. 2, 2 *a*—2 *g*.—HOLASTERELLA CONFERTA, *Carter*.

Figs. 2, 2 *a*—2 *d*.—Fragmentary six-rayed spicules of the skeleton, free or partially cemented together. 2 *a* is magnified forty diameters, and the others twenty diameters. From Lower Carboniferous, highest bed of the Upper Limestone series, near Dalry, Ayrshire. The original specimens in the collection of Mr. H. J. Carter, F.R.S.

Figs. 2 *e*, 2 *f*, 2 *g*.—Small stellate spicules. Magnified forty diameters. From the type-specimen in the collection of Mr. James Thomson, F.G.S.

Figs. 3, 3 *a*—3 *h*.—ASTERACTINELLA EXPANSA, *Hinde*.

Figs. 3, 3 *a*—3 *d*.—Various forms of skeletal-spicules. With the exception of 3 *c*, which is magnified twenty diameters, the spicules are enlarged ten diameters.

Fig. 3 *e*.—A corolla-like spicule, showing the upper surface. Magnified twenty diameters.

Fig. 3 *f*.—A similar spicule, showing the under surface. Magnified ten diameters.

Figs. 3 *g*, 3 *h*.—Small irregular stellate spicules. Magnified twenty diameters.

From the Lower Carboniferous, upper part of the Lower Limestone series, at Law Quarry, Dalry, Ayrshire. The original specimens in the collection of Mr. J. Smith, Kilwinning.

Figs. 4, 4 *a*—4 *i*.—ACANTHACTINELLA BENNIEI, *Hinde*.

Different forms of detached skeletal-spicules. Enlarged ten diameters. Lower Carboniferous, upper part of the Lower Limestone series, at Law Quarry, and Cunningham Baidland, Dalry, Ayrshire. The original specimens in the collections of Mr. J. Smith, Mr. J. Young, F.G.S., and Mr. J. Bennie.

Figs. 5, 5 *a*.—THOLIASTERELLA CRASSA, *Hinde*, sp. nov.

Two detached skeletal-spicules. Enlarged ten diameters. Lower Carboniferous, lower part of the Lower Limestone series, Crawfield Quarry, Beith. The original specimens in the collection of Mr. J. Young, F.G.S.

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PALÆOZOIC SPONGES

PLATE IX.

Figs. 1, 1 *a*—1 *g*—Asteractinella tumida, *Hinde*, sp. nov.

Figs. 1, 1 *a*—1 *f*.—Various forms of skeletal-spicules. Enlarged ten diameters.

Fig. 1 *g*.—A fragment of the skeleton of the Sponge, showing the irregular arrangement of the large and smaller spicules. Enlarged twenty diameters. From the Lower Carboniferous, upper part of the Lower Limestone series at Law Quarry, Dalry, Ayrshire. The original specimens in the collections of Mr. J. Smith and Mr. Bennie.

Figs. 2 2 *a*, 2 *b*.—Tholiasterella crassa, *Hinde*, sp. nov.

Figs. 2, 2 *a*.—Fragments of the skeleton of the Sponge, showing the arrangement of the spicules and the partial welding of the rays of adjacent forms. Enlarged ten diameters.

Fig. 2 *b*.—An "umbrella"-shaped spicule in which the rays are very inequally developed. The vertical ray has been broken off. Enlarged ten diameters. From the Lower Carboniferous, lower part of Lower Limestone series at Crawfield Quarry, Beith, Ayrshire. The original specimens in the collection of Mr. John Young, F.G.S.

Figs. 3, 3 *a*—3 *e*.—Hindia fibrosa, *Roemer* sp.

Fig. 3.—Portion of a longitudinal section, showing the spicular mesh, which has been replaced by calcite. Enlarged sixty diameters.

Fig. 3 *a*.—Portion of a transverse section of the same specimen, showing the canals bounded by the spicular mesh. From limestones of Ordovician Age at Craighead, Girvan, Ayrshire.

Fig. 3 *b*.—Portion of a longitudinal section, showing the spicular mesh. The structure has been replaced by calcite, and the junction of the spicules with each other is only faintly shown. Enlarged one hundred diameters. From Silurian strata at Dalhousie, New Brunswick.

Figs. 3 *c*, 3 *d*, 3 *e*.—Three detached spicules of the Sponge. Enlarged eighty diameters. The spicules retain their siliceous structure; they are, however, much eroded by fossilization. From a specimen from Dalhousie. The original examples are in my collection.

Figs. 4, 4 *a*—4 *e*.—Peronella sparsa, *Hinde*, sp. nov.

Figs. 4, 4 *a*—4 *c*.—Detached three-rayed spicules referred to this species. Enlarged sixty diameters.

Figs. 4 *d*—4 *e*.—Smaller four-rayed spicules. Enlarged sixty diameters. From Lower Carboniferous at Woodend, Cowdens, Fife, Scotland. Collection of Mr. J. Bennie.

Figs. 5, 5 *a*, 5 *b*.—Reniera clavata, *Hinde*, sp. nov.

Detached skeletal-spicules. Enlarged sixty diameters. From the Chert Sponge-beds of the Yoredale series at Richmond, Yorkshire, and Henblas, Flintshire. My collection.

Figs. 6, 6 *a*, 6 *b*.—Reniera virga, *Hinde*, sp. nov.

Detached skeletal-spicules. Enlarged sixty diameters. From the Carboniferous Limestone at Clitheroe, Lancashire, and from the Yoredale Sponge-beds at Richmond, Yorkshire.

Figs. 7, 7 *a*—7 *b*.—Reniera gracilis, *Hinde*.

Detached skeletal-spicules. Enlarged sixty diameters. From the Sponge-beds of the Yoredale series at Richmond, Yorkshire. My collection.

Figs. 8, 8 *a*—8 *c*.—Reniera Zitteli, *Počta*.

Detached skeletal-spicules. Enlarged sixty diameters. From the Sponge-beds of the Yoredale series at Halkin and Henblas, Flintshire. My collection.

Fig. 9.—Reniera bacillum, *Hinde*, sp. nov.

Detached skeletal-spicules. Enlarged sixty diameters. From the Sponge-beds of the Yoredale series at Trelogan, Flintshire.

Fig. 10.—Axinella paxillus, *Hinde*, sp. nov.

A detached skeletal-spicule. Enlarged forty diameters. From the Carboniferous Limestone at Clitheroe, Lancashire.

Figs. 11, 11 *a*, 11 *b*.—Geodites hastatus, *Hinde*, sp. nov.

Fig. 11.—A trifid zone-spicule. Enlarged forty diameters.

Figs. 11 *a*, 11 *b*.—Two detached acerate spicules, similarly enlarged. From the Carboniferous Limestone at Clitheroe, Lancashire. My collection.

Figs. 12, 12 *a*—12 *e*.—Geodites cornutus, *Hinde*, sp. nov.

Fig. 12.—A trifid zone-spicule. Enlarged forty diameters.

Fig. 12 *a*.—A trifid so-called anchor-spicule, similarly enlarged.

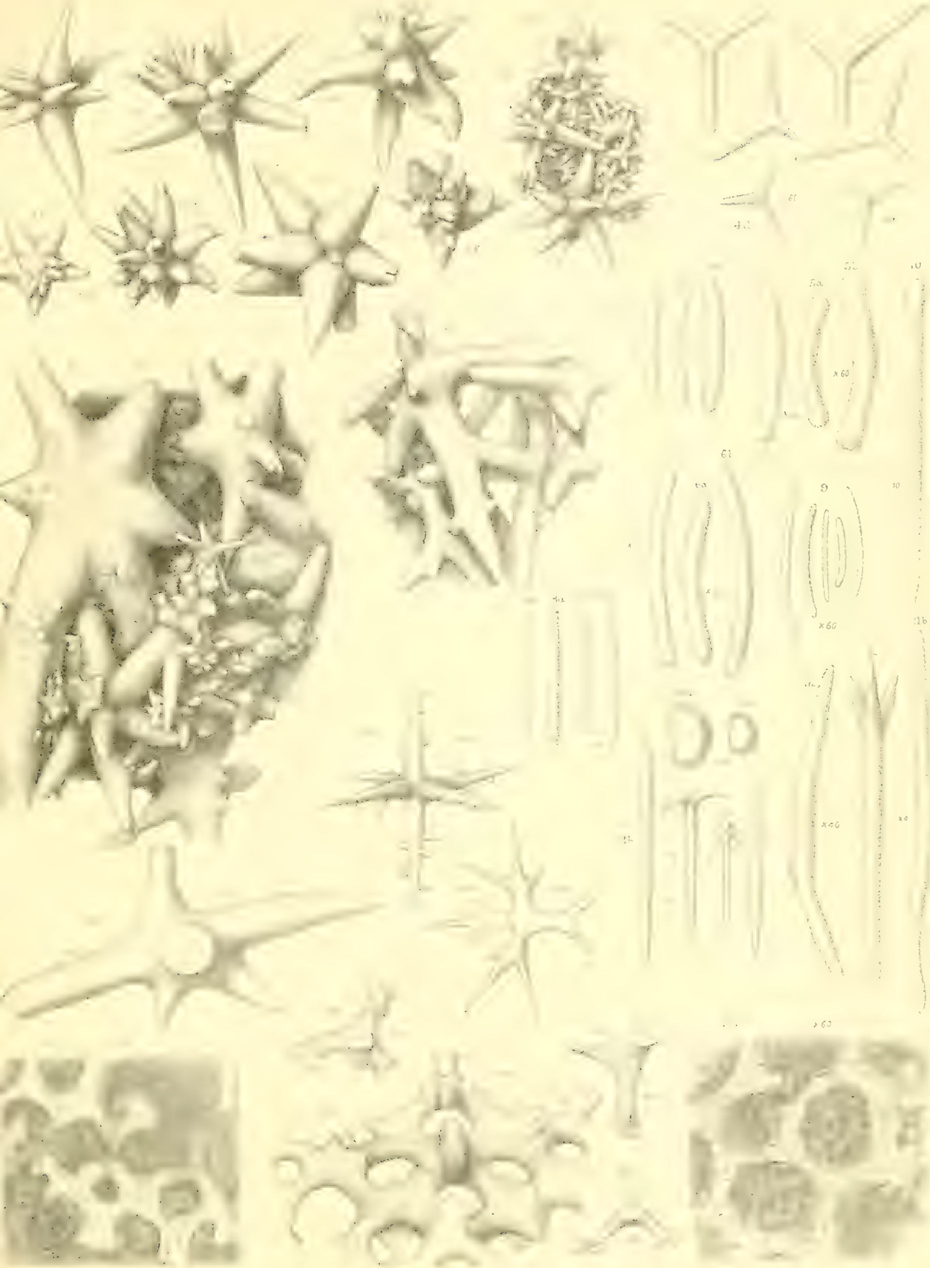
Figs. 12 *b*, 12 *c*.—Two acerate skeletal-spicules, similarly enlarged.

Figs. 12 *d*, 12 *e*.—Two reniform spicules of the dermal layer of the Sponge. Enlarged sixty diameters. From the Chert Sponge-beds of the Yoredale series at Richmond, Yorkshire, and Henblas and Trelogan, Flintshire. My collection.

Figs. 13, 13 *a*.—Flesh Spicules of Hexactinellid Sponges.

Fig. 13.—A detached flesh-spicule with spinous rays. Enlarged two hundred diameters. From the Chert Sponge-beds of the Yoredale series at Richmond, Yorkshire.

Fig. 13 *a*.—An imperfect flesh-spicule. Enlarged one hundred diameters. From a boulder of Carboniferous Chert in the Drift at York. My collection.



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PALÆOZOIC SPONGES

PLATE X.

Figs. 1, 1 *a*.—Tremadictyon sparsum, *Hinde*, sp. nov. (Page 195.)

Fig. 1.—The upper portion of a large cup-shaped example, showing the inner surface of the wall. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, Burton Bradstock, Dorset. Walton Collection, Woodwardian Museum, Cambridge.

Fig. 1 *a*.—Portion of a thin section of the same taken at right angles to the surface, showing the spicular structure, now replaced by calcite. Enlarged 50 diameters.

Figs. 2, 4.—Tremadictyon incertum, *Hinde*, sp. nov. (Page 196.)

Fig. 2.—Portion of a thin section, showing the spicular structure. Enlarged 50 diameters.

Fig. 4.—A cup-shaped specimen. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, Burton Bradstock. (Collection G. J. Hinde.)

Fig. 3.—Tremadictyon reticulatum, *Goldfuss*, sp. (Page 196.)

A fragment of the spicular mesh of this species, retaining the original siliceous structure. Enlarged 50 diameters. From a specimen from the Upper Jura of Streitberg.

Figs. 5, 5 *a*.—Stauroderma explanatum, *Hinde*, sp. nov. (Page 202.)

Fig. 5.—A fragment of a platter-shaped specimen, showing the oscular apertures of the upper or inner surface of the wall. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, Burton Bradstock. (Collection Rev. G. F. Whidborne).

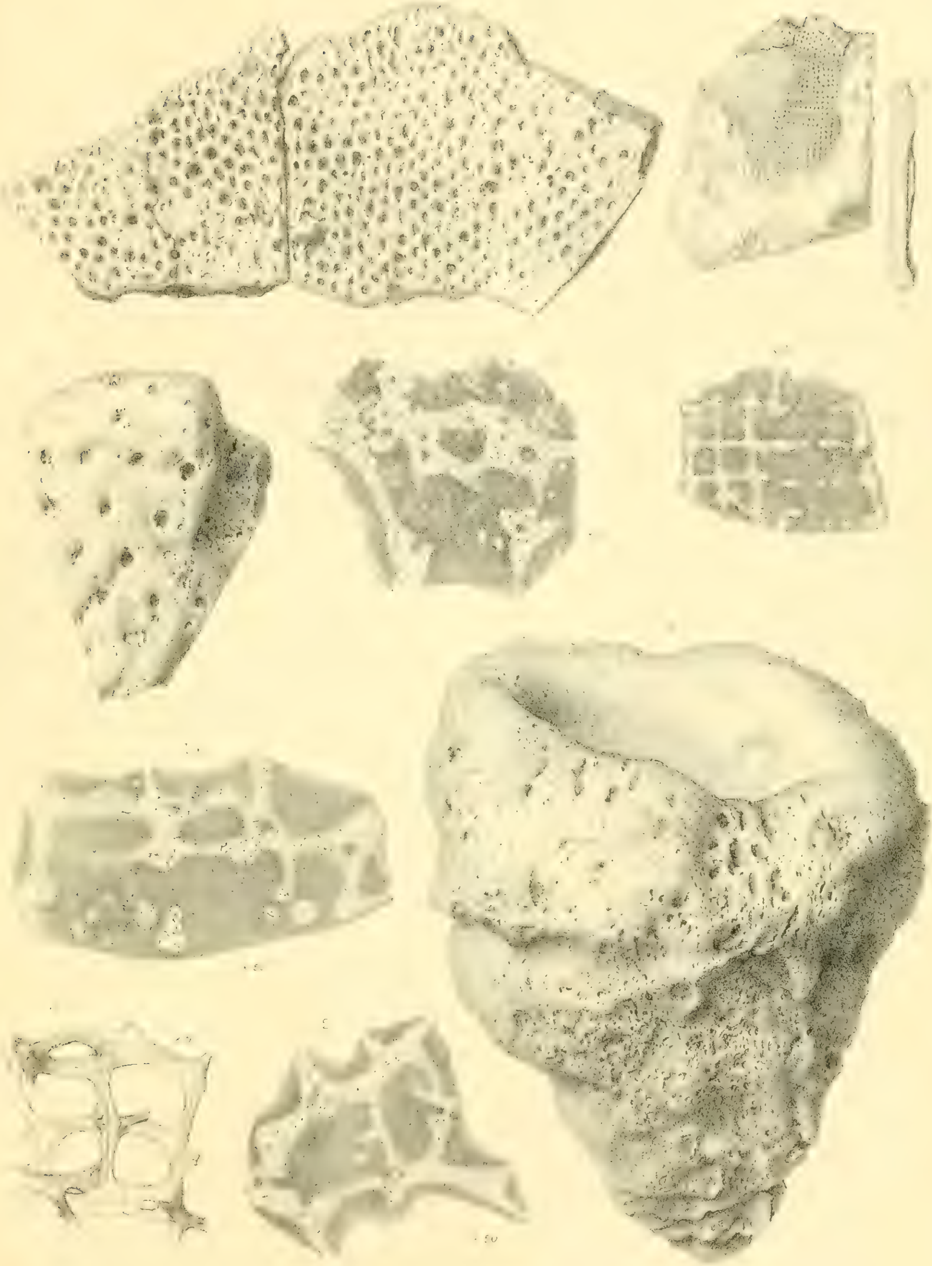
Fig. 5 *a*.—Portion of a transverse section through the wall of the same, showing the spicular structure. Enlarged 50 diameters.

Figs. 6—6 *b*.—Craticularia foliata, *Quenstedt*, sp. (Page 199.)

Fig. 6.—A fragment of the plate-like wall, showing the outer surface. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. (Collection Rev. G. F. Whidborne.)

Fig. 6 *a*.—Another fragment of the same, showing the thickness of the wall.

Fig. 6 *b*.—Portion of a transverse section of the wall, showing the spicular structure now replaced by calcite. Enlarged 50 diameters.



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JURASSIC SPONGES

West, Newman imp.

PLATE XI.

Figs. 1—1 *c*.—Calathiscus variolatus, *Sollas*. (Page 197.)

Fig. 1.—A nearly complete specimen, showing the character of the outer surface, somewhat injured by weathering. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. The type of the species. (Collection Rev. G. F. Whidborne.)

Fig. 1 *a*.—The imperfect upper portion of another specimen from the same place, showing traces of the apertures on the inner surface of the wall. Natural size. (Collection Rev. G. F. Whidborne.)

Figs. 1 *b*, 1 *c*.—Portions of sections of the sponge-wall, showing the spicular structure, now replaced by calcite. Enlarged 50 diameters.

Figs. 2, 2 *a*.—Verrucocœlia Whidborni, *Sollas*, sp. (Page 200.)

Fig. 2.—A nearly complete specimen, showing the upper surface. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, Burton Bradstock. The type of the species. (Collection Rev. G. F. Whidborne.)

Fig. 2 *a*.—Portion of a section of the wall, showing the spicular structure. Enlarged 50 diameters.

Figs. 3, 3 *a*.—Verrucocœlia elegans, *Sollas*, sp. (Page 201.)

Fig. 3.—The type of the species. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, Burton Bradstock. (Collection Rev. G. F. Whidborne.)

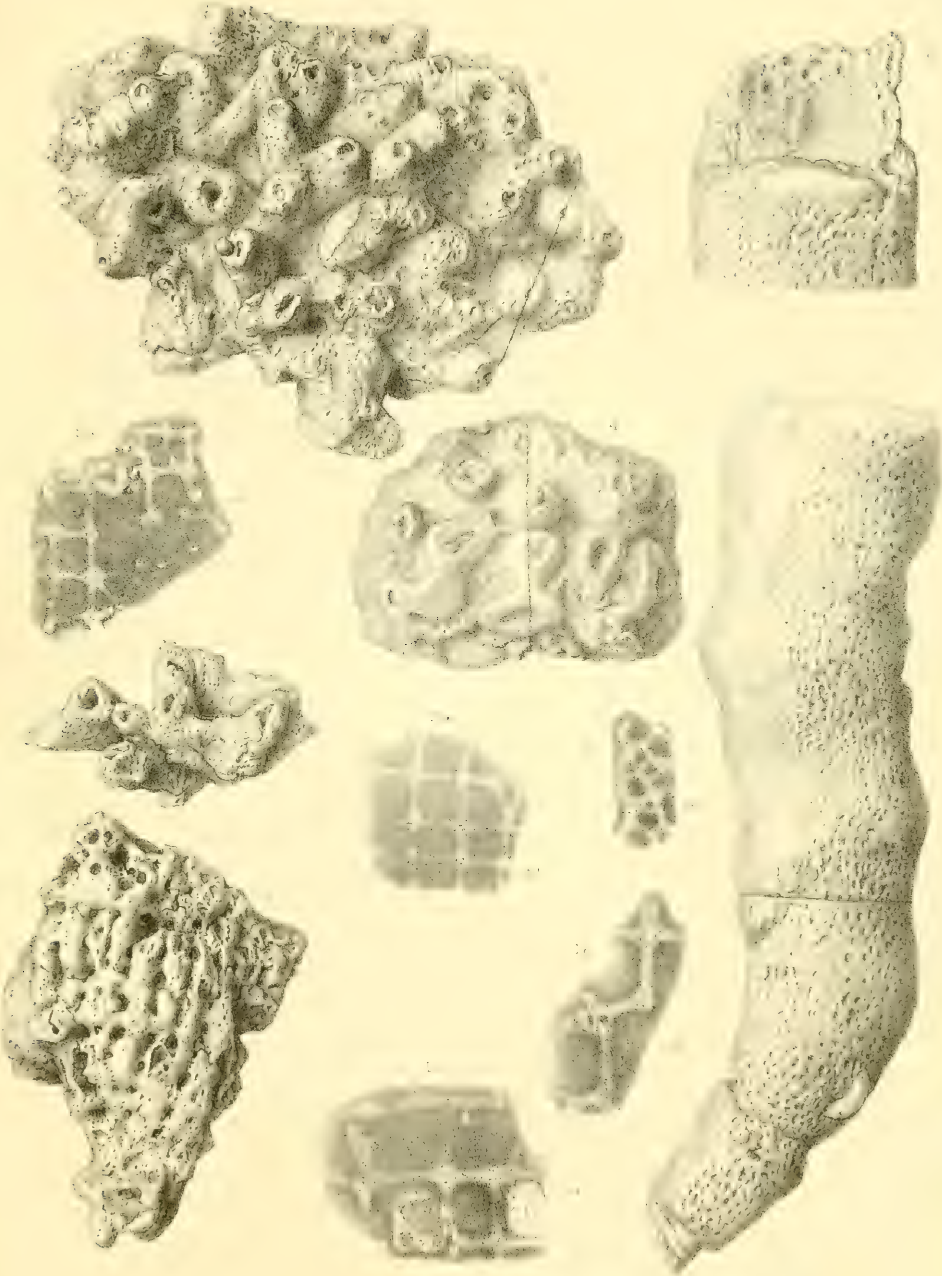
Fig. 3 *a*.—A portion of the sponge wall, showing the spicular structure. Enlarged 50 diameters.

Fig. 4.—Verrucocœlia major, *Sollas*, sp. (Page 201.)

The type of the species, showing the summits of the spongites weathered out on the surface of a limestone nodule. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. (Collection Rev. G. F. Whidborne.)

Fig. 5.—Craticularia clathrata, *Goldfuss*, sp. (Page 198.)

An incomplete specimen, showing the characters of the outer surface, but partially obscured by weathering. Natural size. Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. Walton Collection, Woodwardian Museum, Cambridge.



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JURASSIC SPONGES

West, Newman imp.

PLATE XII.

Figs. 1, 1 *a*.—Leiodorella contorta, *Hinde*, sp. nov. (Page 206.)

Fig. 1.—A specimen showing the outer surface of the wall with the oscules, now enlarged by weathering. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. (Collection G. J. Hinde.)

Fig. 1 *a*.—Portion of a transverse section of the sponge, showing the spicular structure, now replaced by calcite. Enlarged 20 diameters.

Figs. 2—2 *b*.—Platychonia elegans, *Sollas*. (Page 204.)

Fig. 2.—A nearly complete specimen, growing attached to the surface of *Calathiscus variolatus*, showing the reticulation of the upper surface of the wall. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. (Collection G. J. Hinde.)

Fig. 2 *a*.—Another specimen from the same locality, showing the under surface. (Collection Rev. G. F. Whidborne.)

Fig. 2 *b*.—Portion of a transverse section, showing the spicular structure. Enlarged 50 diameters.

Fig. 3.—Platychonia vagans, *Quenstedt*, sp. (Page 205.)

A small fragment of the spicular mesh of this species, showing the spicules in their original siliceous condition. Enlarged 50 diameters. Figured for comparison with the preceding. The sponge is from the Upper or White Jura of Streitberg, Germany.

Figs. 4, 4 *a*.—Platychonia Brodiei, *Sollas*. (Page 204.)

Fig. 4.—The type-specimen. Natural size. From the Marlstone of the Middle Lias, Ilminster, Somerset. (Collection Rev. P. B. Brodie.)

Fig. 4 *a*.—A median section of the same, showing the thickness of the wall. This figure and the preceding are copied from the figures given by Sollas in 'Proc. Roy. Dubl. Soc.,' N. S., vol. xli, pl. xxi.

Figs. 5, 5 *a*.—Platychonia affinis, *Hinde*, sp. nov. (Page 205.)

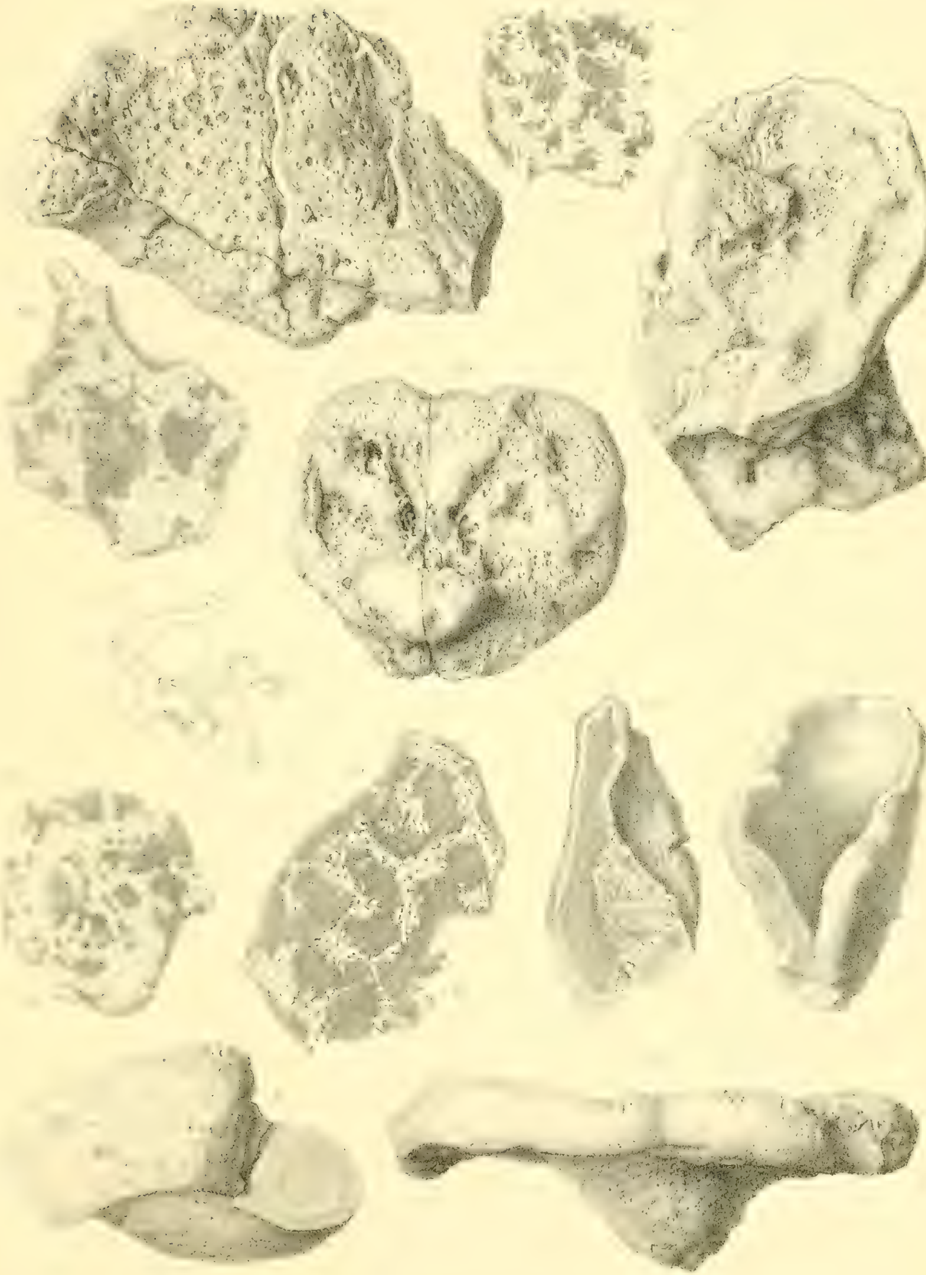
Fig. 5.—The type-specimen. Natural size. Inferior Oolite, *Parkinsoni*-zone, Burton Bradstock. (Collection G. J. Hinde.)

Fig. 5 *a*.—A portion of a transverse section, showing the spicular structure now replaced by calcite. Enlarged 20 diameters.

Figs. 6, 6 *a*.—Platychonia tenuis, *Hinde*, sp. nov. (Page 205.)

Fig. 6.—A convolute specimen. Natural size. The wall on the right of the specimen has been cut through to show its thickness. Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. (Collection G. J. Hinde.)

Fig. 6 *a*.—A portion of a section, showing the spicular structure now replaced by calcite. Enlarged 50 diameters.



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JURASSIC SPONGES

West, Newman imp

PLATE XIII.

Figs. 1—1 *c*.—Melonella ovata, *Sollas*, sp. (Page 207.)

Figs. 1, 1 *a*.—The type-forms of the species. Natural size. Inferior Oolite, *Humphresianus*-zone, at Dundry Hill, near Bristol. (Collection Rev. G. F. Whidborne.)

Fig. 1 *b*.—A portion of a vertical median section of one of the specimens, showing the spicular structure, now replaced by calcite. Enlarged 50 diameters.

Fig. 1 *c*.—A portion of the surface of 1 *a*, showing the weathered-out spicular nodes. Enlarged 50 diameters.

Figs. 2, 2 *a*.—Cylindrophyma milleporatum, *Goldfuss*, sp. (Page 208.)

Detached siliceous spicules of this species. Enlarged 50 diameters. From the Upper White Jura of Beuren, Germany. Figured for comparison with the preceding.

Figs. 3, 4.—Pachastrella antiqua, *Moore*, sp. (Page 208.)

Fig. 3.—Detached caltrop spicules of this species. Enlarged 20 diameters. From chert in the Portland Beds, Isle of Portland. Museum of the Geological Survey, Jermyn Street.

Fig. 4.—A section of Lower Lias Limestone, showing spicules of this species intermingled with others, all of them now replaced by calcite. Enlarged 20 diameters. Lower Lias, Shepton Mallet, Somersetshire.

Fig. 5.—Geodites, sp. (*a*). (Page 209.)

An imperfect trifid spicule. Enlarged 20 diameters. From the cherty bands in the Portland Limestone, Isle of Portland.

Fig. 5 *a*.—Geodites, sp. (*b*). (Page 210.)

An imperfect trifid and a simple acerate spicule, probably belonging to the same species. Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock.

Figs. 6, 6 *a*.—Spongilla Purbeckensis, *Young*. (Page 212.)

Fig. 6.—A section of chert filled with the spicules of this species. Enlarged 50 diameters. From the Purbeck Limestones at Stare Cove, Lulworth, Dorsetshire.

Fig. 6 *a*.—Longitudinal, oblique, and transverse sections of some of the spicules. Enlarged 100 diameters.

Figs. 7—7 *f*.—Rhaxella perforata, *Hinde*. (Page 210.)

Fig. 7.—An imperfect specimen, partially weathered out of a slab of rock. Natural size. From the Lower Calcareous Grit, Scarborough, Yorkshire. York Museum.

Fig. 7 *a*.—A fragment of another specimen, showing the slit-like apertures in the wall. Natural size.

Fig. 7 *b*.—A transverse section of the same piece, showing the disposition of the wall-laminæ. Natural size.

Fig. 7 *c*.—A thin section of a fragment of the wall, showing its composition of globate spicules. Enlarged 20 diameters.

Fig. 7 *d*.—Some of the detached spicules, showing variations in form and size.

Fig. 7 *e*.—A single spicule, mounted in glycerine, showing traces of its component rods. Enlarged 200 diameters.

Fig. 7 *f*.—Anotiher specule, similarly enlarged, showing the surface structure.

PLATE XIII

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PLATE XIV.

Figs. 1—1 *d*.—Peronidella pistilliformis, *Lamouroux*, sp. (Page 213.)

Figs. 1—1 *b*.—Three separate colonies, showing variations in the mode of growth, and in the size and disposition of the individual spongites. Natural size. All from the Great Oolite at Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge (Walton Collection).

Fig. 1 *c*.—Part of a transverse section of the sponge-wall, showing the spicular structure of the fibres. Enlarged 60 diameters.

Fig. 1 *d*.—Two tuning-fork spicules, imperfect, seen in the fibres of the same section. Enlarged 200 diameters.

Figs. 2, 2 *a*.—Peronidella tenuis, *Hinde*. (Page 215.)

Fig. 2.—The type of the species. Natural size. Inferior Oolite, Pea-grit, zone of *Ammonites Murchisonæ*, near Cheltenham. British Natural History Museum.

Fig. 2 *a*.—Part of a transverse section; only traces of three-rayed spicules surrounded by crystalline fibres are shown. Enlarged 60 diameters.

Figs. 3—3 *c*.—Peronidella Waltoni, *Hinde*, sp. nov. (Page 216.)

Fig. 3.—An imperfect specimen, in which a lateral branch grows parallel with the main stem. Natural size.

Fig. 3 *a*.—An imperfect specimen, in which four divergent stems grow from a common centre. Natural size.

Fig. 3 *b*.—An imperfect specimen in which several stumpy branches grow from the main stems. The surface in this specimen is partly smooth, with small perforations. Natural size. All these specimens are from the Great Oolite, Hampton Cliffs, near Bath, and they belong to the Walton Collection in the Woodwardian Museum, Cambridge.

Fig. 3 *c*.—A transverse section of the sponge-wall from the exterior to the cloacal tube, showing the disposition of the fibres. Enlarged 10 diameters.

Figs. 4—4 *f*.—Peronidella Metabronnii, *Sollas*. (Page 215.)

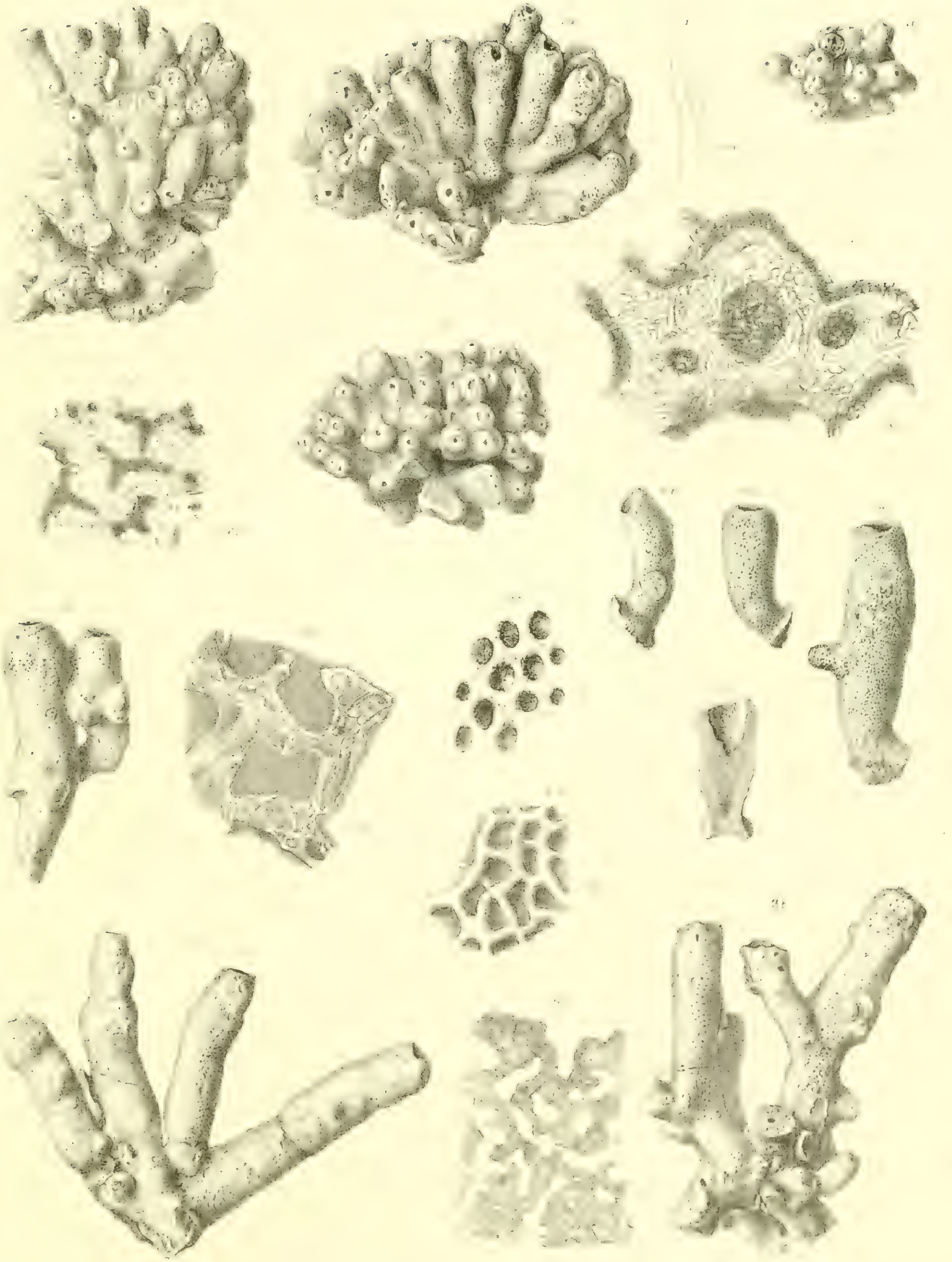
Figs. 4—4 *b*.—Three specimens, showing variations in form and mode of growth. Natural size. In fig. 4 a young specimen of the same species has attached itself to the surface of the larger, and in 4 *b* a small specimen of *Holcospongia bella* has fixed itself for support. The forms are all from the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge, near Bridport, Dorset. Collection E. A. Walford.

Fig. 4 *c*.—A vertical median section, showing the thickness of the wall, the form of the cloaca, the lower portion of which is filled by matrix, and the pores in its walls. Natural size.

Fig. 4 *d*.—A portion of the outer surface of the sponge showing the disposition of the fibres. Enlarged 10 diameters.

Fig. 4 *e*.—A portion of the wall of the cloaca showing the regular oval perforations. Enlarged 10 diameters.

Fig. 4 *f*.—A portion of a transverse section of the wall showing the fibres. Enlarged 60 diameters. The spicular structure is nearly wholly obliterated.



Hollick et lith. West Newman imp.

PLATE XV.

Figs. 1—1 *c*.—Peronidella recta, *Hinde*, sp. nov. (Page 217.)

Figs. 1, 1 *a*.—Two of the compound forms, natural size. The transverse groove in fig. 1 is the impress of an Echinoderm spine to which the sponge has been attached. From the Lower Calcareous Grit at Suffield, near Scarborough. (Coll. Mr. S. Chadwick.)

Fig. 1 *b*.—A portion of the outer surface, showing the interspaces between the fibres. Enlarged 10 diameters.

Fig. 1 *c*.—A portion of a transverse section showing the fibres and traces of three-rayed spicules. Enlarged 60 diameters.

Figs. 2—2 *g*.—Peronidella nana, *Hinde*. (Page 218.)

Figs. 2, 2 *a*.—A specimen, natural size, and enlarged 4 diameters.

Figs. 2 *b*—2 *e*.—Different specimens, showing variations in form and size. Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge, Dorset. (Coll. Mr. E. A. Walford.)

Fig. 2 *f*.—A portion of the outer surface showing the irregular interspaces between the fibres. Enlarged 10 diameters.

Fig. 2 *g*.—A portion of a section showing the fibres; the spicular structure has been obliterated. Enlarged 60 diameters.

Figs. 3—3 *h*.—Corynella lycoperdioides, *Lamx.*, sp. (Page 220.)

Figs. 3—3 *c*.—Four specimens of the sponge. Natural size. Fig. 3 *a* is partially lobate, and the stem is wanting; in fig. 3 *b* the stem has also been partially broken off. All the specimens are from the Cornbrash at Langton Herring near Weymouth, and they belong to the Woodwardian Museum at Cambridge.

Figs. 3 *d*, 3 *e*.—Portions of transverse and longitudinal sections, showing the disposition and the spicular structure of the fibres. Enlarged 60 diameters.

Figs. 3 *f*, 3 *g*.—Tuning-fork spicules; in fig. 3 *f* as seen in their natural position in the fibres. Fig. 3 *g* is a single spicule, imperfect, from the same microscopic section. Enlarged 200 diameters.

Fig. 3 *h*.—A sagittate four-rayed spicule from the same sponge. Enlarged 100 diameters.

Figs. 4—4 *b*.—Corynella elegans, *Hinde*, sp. nov. (Page 221.)

Figs. 4, 4 *a*.—A simple individual and a compound specimen. Natural size. From the Great Oolite at Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge, Walton Collection.

Fig. 4 *b*.—A portion of a transverse section, showing the spicular structure of the fibres. Enlarged 60 diameters.

Figs. 5, 5 *a*.—Eusiphonella prolifera, *Hinde*, sp. nov. (Page 219.)

Fig. 5.—An end view of the type-specimen, showing the mode of growth. Natural size. Great Oolite, near Bath. British Natural History Museum.

Fig. 5 *a*.—Portion of a transverse section of one of the spongites, showing the spicular structure of the fibres. Enlarged 60 diameters.

Figs. 6, 6 *a*.—Corynella Chadwicki, *Hinde*, sp. nov. (Page 223.)

Two small examples of this species. Natural size. From the Coralline Oolite, zone of *Ammonites plicatilis*, at Langton Wold, near Malton, Yorkshire. (Coll. Mr. S. Chadwick.)

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JURASSIC SPONGES

PLATE XVI.

Figs. 1—1 *d*.—Corynella Chadwicki, *Hinde*, sp. nov. (Page 223.)

Fig. 1.—A large specimen, natural size. From the Coralline Oolite, *Plicatilis*-zone, at Langton Wold, near Malton, Yorkshire. (Collection Mr. S. Chadwick.)

Fig. 1 *a*.—A vertical median section, showing the cloacal tube and portions of the canals which open into it. Natural size.

Fig. 1 *b*.—A transverse section of another specimen, showing the thickness of the sponge-wall.

Fig. 1 *c*.—A fragment of the outer surface, showing the disposition of the fibres and the irregular pores between them. Enlarged 10 diameters.

Fig. 1 *d*.—Portion of a transverse section, showing the spicular structure of the fibres. Enlarged 60 diameters.

Figs. 2, 2 *a*.—Corynella Langtonensis, *Hinde*, sp. nov. (Page 222.)

Fig. 2.—A specimen from the Coral Rag at Langton Wold. Natural size. (Collection Mr. S. Chadwick.)

Fig. 2 *a*.—A portion of a transverse section of another specimen, showing the spicular fibres. Enlarged 60 diameters.

Figs. 3—3 *c*.—Corynella punctata, *Hinde*, sp. nov. (Page 222.)

Fig. 3.—A single individual. Natural size. From the Oolitic Marl of the Inferior Oolite at Ravensgate Hill, near Cheltenham. Collected by Mr. R. F. Tomes.

Figs. 3 *a*, 3 *b*.—Two small colonies. Natural size. From the same horizon and locality.

Fig. 3 *c*.—A portion of the exterior surface, showing the disposition of the fibres and the irregular ostial apertures. Enlarged 15 diameters.

Figs. 4—4 *f*.—Corynella cribrata, *Hinde*, sp. nov. (Page 224.)

Fig. 4.—A single individual, showing the furrowed character of the wall. Natural size.

Figs. 4 *a*, 4 *b*.—Two small colonies. Natural size. In 4 *a* the spongites scarcely at all project, whilst in 4 *b* they are more extended.

Figs. 4 *c*—4 *e*.—Three colonies showing variations in growth and size of the spongites. Natural size. All the specimens are from the Great Oolite at Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge (Walton Collection).

Fig. 4 *f*.—A portion of a transverse section, showing the spicules forming the fibres. Enlarged 60 diameters.

Figs. 5—5 *e*.—Holcospongia polita, *Hinde*, sp. nov. (Page 228.)

Fig. 5.—A single individual. Natural size.

Figs. 5 *a*—5 *c*.—Three small colonies. Natural size. All from the Lower Coral Rag, *Perarmatus*-zone, at Suffield, Yorkshire. (Collection Mr. S. Chadwick.)

Fig. 5 *d*.—A portion of a transverse section, showing the disposition and the thickness of the fibres. Enlarged 10 diameters.

Fig. 5 *e*.—A portion of the same, showing the spicular character of the fibres. Enlarged 60 diameters.

Figs. 6—6 *c*.—Holcospongia floriceps, *Phillips*, sp. (Page 226.)

Fig. 6.—The type-specimen. Natural size. From the Lower Coral Rag at Hackness, Yorkshire. York Museum.

Fig. 6 *a*.—Another specimen, in which the surface furrows have been obliterated and only the fibrous mesh is shown on the exterior. From the Lower Coral Rag at Suffield, Yorkshire. (Collection Mr. S. Chadwick.)

Fig. 6 *b*.—A single spongite, broken off from a compound mass, showing the lower portion enclosed by a dermal layer. Natural size.

Fig. 6 *c*.—A portion of a transverse section taken from the type-specimen, showing the spicular structure of the fibres. Enlarged 60 diameters.

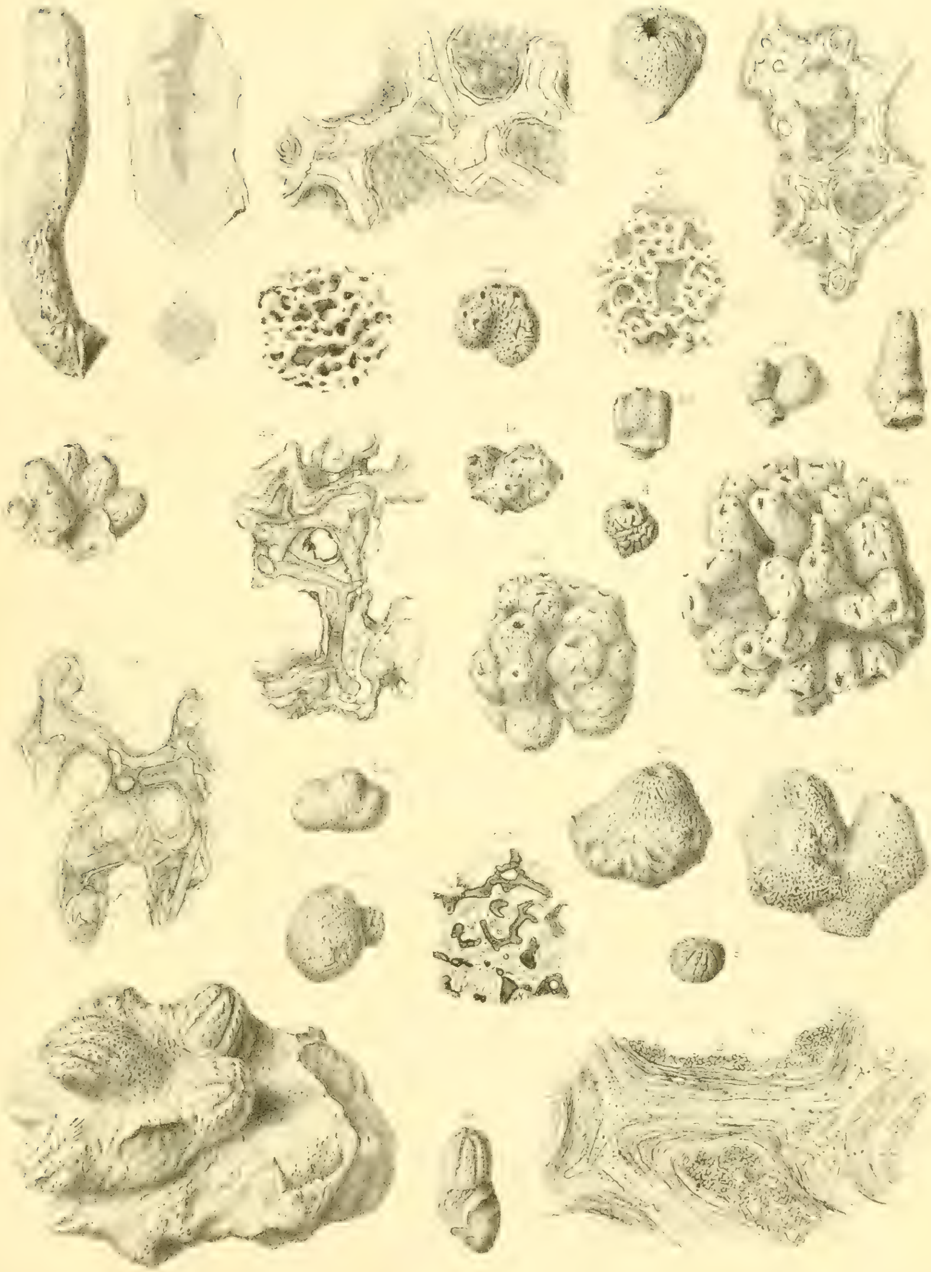

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PLATE XVII.

Figs. 1—1 *c*.—Holcospongia glomerata, *Quenstedt*, sp. (Page 228.)

Fig. 1.—Three simple individuals, attached to the surface of a specimen of *Corynella Chadwicki*. Natural size.

Fig. 1 *a*.—An ovate specimen, natural size. This and the preceding are from the Coralline Oolite, *Plicatilis*-zone, at Langton Wold, Malton, Yorkshire. (Collection Mr. S. Chadwick.)

Fig. 1 *b*.—Portion of a transverse section, enlarged 10 diameters, showing the disposition of the fibres.

Fig. 1 *c*.—Part of the same section, enlarged 60 diameters, showing the spicular structure of the fibres.

Fig. 2.—Holcospongia floriceps, *Phillips*, sp. (Page 226.)

Portion of a transverse section, enlarged 10 diameters, showing the disposition of the fibres.

Figs. 3—3 *h*.—Holcospongia sulcata, *Hinde*, sp. nov. (Page 229.)

Figs. 3, 3 *a*.—A specimen, enlarged 3 diameters, showing the upper (3 *a*) and under (3) surfaces.

Figs. 3 *b*—3 *e*.—Two specimens, natural size, showing the upper (3 *c*, 3 *e*) and the under (3 *b*, 3 *d*) surfaces.

Fig. 3 *f*.—Another specimen, showing the upper surface. Natural size.

Fig. 3 *g*.—Another specimen viewed laterally, showing the thickness and the curvature of the wall. Natural size. All the specimens are from the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge, near Bridport. (Collection Mr. E. A. Walford.)

Fig. 3 *h*.—A portion of a transverse section of the fibres, enlarged 60 diameters.

Figs. 4—4 *d*.—Holcospongia contorta, *Hinde*, sp. nov. (Page 230.)

Fig. 4.—A club-shaped specimen, enlarged 2 diameters, showing the grooved surface.

Fig. 4 *a*.—A small specimen, attached to a fragment of shell. Enlarged 4 diameters.

Figs. 4 *b*, 4 *c*.—Small pisiform specimens. Natural size. All the specimens are from the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge. (Collection Mr. E. A. Walford.)

Fig. 4 *d*.—A portion of the surface of the dermal layer, showing large three-rayed spicules and traces of smaller ones beneath. Enlarged 60 diameters.

Figs. 5—5 *c*.—Holcospongia liasica, *Quenstedt*, sp. (Page 231.)

Figs. 5, 5 *a*.—The upper and under surface of the same specimen. Natural size.

Fig. 5 *b*.—A compound specimen, in which one individual is partially overgrowing another. Natural size. The specimens are from the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge. (Collection Mr. E. A. Walford.)

Fig. 5 *c*.—Portion of a transverse section, showing the spicular fibres. Enlarged 60 diameters.

Figs. 6—6 *e*.—Holcospongia bella, *Hinde*, sp. nov. (Page 232.)

Fig. 6.—A specimen showing the upper surface. Enlarged 3 diameters.

Figs. 6 *a*—6 *c*.—The upper, lower, and side views of the same specimen. Natural size.

Fig. 6 *d*.—A specimen showing the upper surface. All the specimens are from the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge, Dorset. (Collection Mr. E. A. Walford.)

Fig. 6 *e*.—Portion of a transverse section, showing the spicular fibres surrounded by crystalline calcite. Enlarged 60 diameters.

Figs. 7—7 *d*.—Holcospongia mitrata, *Hinde*, sp. nov. (Page 232.)

Figs. 7—7 *b*.—Three different specimens. Enlarged 4 diameters. From the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge. (Collection Mr. E. A. Walford.)

Fig. 7 *c*.—A portion of the outer surface, showing the ostia. Enlarged 10 diameters.

Fig. 7 *d*.—A portion of the dermal layer, showing some of the component three-rayed spicules. Enlarged 60 diameters.

Fig. 8.—Myrmecium biretiforme, *Sollas*. (Page 233.)

The type-specimen referred to this species, showing the summit. Natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Burton Bradstock. (Collection Rev. G. F. Whidborne.)

Figs. 9—9 *c*.—Elasmostoma palmatum, *Hinde*, sp. nov. (Page 243.)

Figs. 9, 9 *a*.—Two small fan-shaped specimens. Natural size. In Fig. 9 the dermal layer has been removed; in 9 *a* the under or non-oscular surface is shown.

Fig. 9 *b*.—A lobate specimen, the surface partially covered with the dermal layer. Natural size. All the specimens are from the Great Oolite, Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge (Walton Collection).

Fig. 9 *c*.—A portion of a transverse section, showing the spicular structure of the fibres. Enlarged 60 diameters.

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PLATE XVIII.

Figs. 1, 1 *a*.—Elasmostoma palmatum, *Hinde*, sp. nov. (Page 243.)

Fig. 1.—A specimen showing the upper or oscular surface. Natural size. The dermal layer is only partly preserved. Several small oysters are attached to it. From the Great Oolite at Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge (Walton Collection).

Fig. 1 *a*.—A portion of the dermal layer of another specimen, showing three-rayed spicules weathered out on the surface. Enlarged 60 diameters.

Figs. 2—2 *c*.—Lymnorella mamillosa, *Lamx.* (Page 235.)

Fig. 2.—A large specimen showing the upper surface, with its oscules and ostia. Natural size. From the Inferior Oolite, Pea-grit series, at Crickley Hill, near Cheltenham. (Collection Mr. R. F. Tomes.)

Fig. 2 *a*.—Portion of a transverse section, showing the tubular excurrent canals or cloacæ; the horizontal canals and the small incurrent canals connected with the ostia. Enlarged 2 diameters.

Fig. 2 *b*.—A vertical section, natural size, showing concentric zones of growth and excurrent canals.

Fig. 2 *c*.—Portion of a microscopic section, showing the axial spicules and the crystalline condition of the fibres. Enlarged 60 diameters.

Figs. 3—3 *d*.—Lymnorella inclusa, *Hinde.* (Page 236.)

Fig. 3.—A specimen with a flattened base, showing the upper surface and successive layers of growth. Small sunken oscules are shown, and one or two small oysters are attached to the surface. Natural size. Inferior Oolite, Pea-grit, Crickley Hill, near Cheltenham. (Collection Mr. R. F. Tomes.)

Fig. 3 *a*.—The type of the species. Natural size. From the Pea-grit, near Cheltenham. British Natural History Museum.

Fig. 3 *b*.—Part of a vertical section, showing the disposition of the fibres. Enlarged 10 diameters.

Fig. 3 *c*.—Part of a thickened fibre, showing the axial three-rayed spicules and the radiately crystalline character of the fibre. Enlarged 60 diameters.

Fig. 3 *d*.—A tuning-fork spicule from the fibre of the same section as 3 *c*. Enlarged 200 diameters.

Figs. 4—4 *b*.—Lymnorella pygmæa, *Sollas.* (Page 238.)

Fig. 4.—A compound specimen, showing the spongites and the dermal layer. Natural size. Inferior Oolite, Shipton Gorge. (Collection Mr. E. A. Walford.)

Fig. 4 *a*.—A specimen showing the conical spongites of the upper surface. Natural size. Inferior Oolite, Pea-grit series, near Cheltenham.

Fig. 4 *b*.—A simple individual. Natural size. Inferior Oolite, at Shipton Gorge. (Collection Mr. E. A. Walford.)

Figs. 5—5 *d*.—Lymnorella micula, *Hinde.* (Page 239.)

Figs. 5, 5 *a*.—Two nodose somewhat lobate specimens, showing traces of zonal layers of growth. Natural size. From the Great Oolite at Hampton Cliffs, near Bath. Woodwardian Museum, Cambridge (Walton Collection).

Fig. 5 *b*.—A portion of a vertical section, showing the spicular fibres. Enlarged 60 diameters.

Fig. 5 *c*.—A very perfect tuning-fork spicule, from the outer portion of the fibres. Enlarged 200 diameters.

Fig. 5 *d*.—Two three-rayed spicules from the surface of the dermal layer. Enlarged 60 diameters.

Figs. 6—6 *b*.—Lymnorella ramosa, *Hinde*, sp. nov. (Page 238.)

Fig. 6.—A specimen seen from the under surface, showing the branches growing from a basal stock. Natural size. From the Inferior Oolite at Andoversford, near Cheltenham. Collected by Mr. R. F. Tomes.

Fig. 6 *a*.—A portion of the surface, enlarged 10 diameters, showing a group of the larger apertures.

Fig. 6 *b*.—A portion of a transverse section, showing the spicular fibres. Enlarged 60 diameters.

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JURASSIC SPONGES

PLATE XIX.

Figs. 1—1 *c*.—Eudea Walfordi, *Hinde*, sp. nov. (Page 241.)

Figs. 1, 1 *a*, 1 *b*.—Three specimens, each enlarged 3 diameters. The outline figures represent the natural size. From the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge, Dorset. (Collection Mr. E. A. Walford.)

Fig. 1 *c*.—A transverse section through a specimen, showing the cloacal tube and the disposition of the fibres. Enlarged 10 diameters.

Figs. 2—2 *b*.—Eudea pisum, *Quenstedt*, sp. (Page 242.)

Three specimens, each enlarged 3 diameters. From the Inferior Oolite at Shipton Gorge. (Collection Mr. E. A. Walford.)

Figs. 3, 3 *a*.—Diaplectia auricula, *Hinde*. (Page 245.)

Fig. 3.—The type-specimen, showing the outer surface of the wall. Natural size. From the Inferior Oolite, Pea-grit series, near Cheltenham. British Nat. Hist. Museum.

Fig. 3 *a*.—Portion of a transverse section, showing the spicular fibres. Enlarged 60 diameters.

Figs. 4, 4 *a*.—Diaplectia infundibulum, *Hinde*, sp. nov. (Page 245.)

Fig. 4.—The type-specimen. Natural size. From the Great Oolite at Bradford, Wiltshire. Woodwardian Museum, Cambridge.

Fig. 4 *a*.—Portion of the inner surface, showing the character of the interspaces between the fibres. Enlarged 10 diameters.

Figs. 5—5 *c*.—Blastinia costata, *Goldfuss*, sp. (Page 246.)

Fig. 5.—A specimen showing the ridged upper surface. Enlarged 4 diameters. From Jurassic strata in the Richmond (Surrey) well-boring, at 1205 feet beneath the surface.

Figs. 5 *a*, 5 *b*.—Two specimens, showing the ridges of the upper surface. The depressions are partially filled with matrix. Enlarged 2 diameters. From the Oolite-Marl of the Inferior Oolite at Ravensgate Hill, near Cheltenham. Collected by Mr. R. F. Tomes.

Fig. 5 *c*.—Portion of a transverse section of a specimen from Ravensgate Hill, showing the spicular fibres. Enlarged 60 diameters.

Figs. 6—6 *d*.—Blastinia aspera, *Hinde*, sp. nov. (Page 247.)

Fig. 6.—A conical specimen with flattened base. Natural size.

Fig. 6 *a*.—A compound specimen, showing several ridged individuals growing on a common base. Natural size.

Fig. 6 *b*.—A simple specimen with laterally corrugated ridges or crests. Natural size. All the specimens are from the Coral Rag at Suffield, Yorkshire. (Collection Mr. S. Chadwick.)

Fig. 6 *c*.—A portion of a transverse section, showing the great thickness of the skeletal fibres in the ridges. Enlarged 10 diameters.

Fig. 6 *d*.—Another portion, showing the spicular structure of the fibres. Enlarged 60 diameters.

Figs. 7—7 *b*.—Oculospongia minuta, *Hinde*. (Page 240.)

Fig. 7.—A specimen showing a lateral view, natural size, and the upper surface enlarged 3 diameters. From the Inferior Oolite, *Parkinsoni*-zone, at Shipton Gorge, Dorset. (Collection Mr. E. A. Walford.)

Fig. 7 *a*.—Another specimen, showing the upper surface, on which a *Serpula* is attached. Enlarged 4 diameters. From the Jurassic Strata in the Richmond (Surrey) well-boring, at a depth of 1205 feet below the surface.

Fig. 7 *b*.—Portion of a transverse section of a specimen from Shipton Gorge, showing the spicular structure of the fibres. Enlarged 60 diameters.

Figs. 8—8 *x*.—Leucandra Walfordi, *Hinde*. (Page 248.)

Figs. 8—8 *c*.—Four specimens showing their mode of growth. Enlarged 10 diameters. The outline figure near the base of each represents the natural size. The specimens are all from the Marlstone of the Middle Lias at King's Sutton, Northamptonshire. Collected by Mr. E. A. Walford.

Fig. 8 *d*.—The summit of a specimen showing the aperture of the cloacal tube. Enlarged 10 diameters.

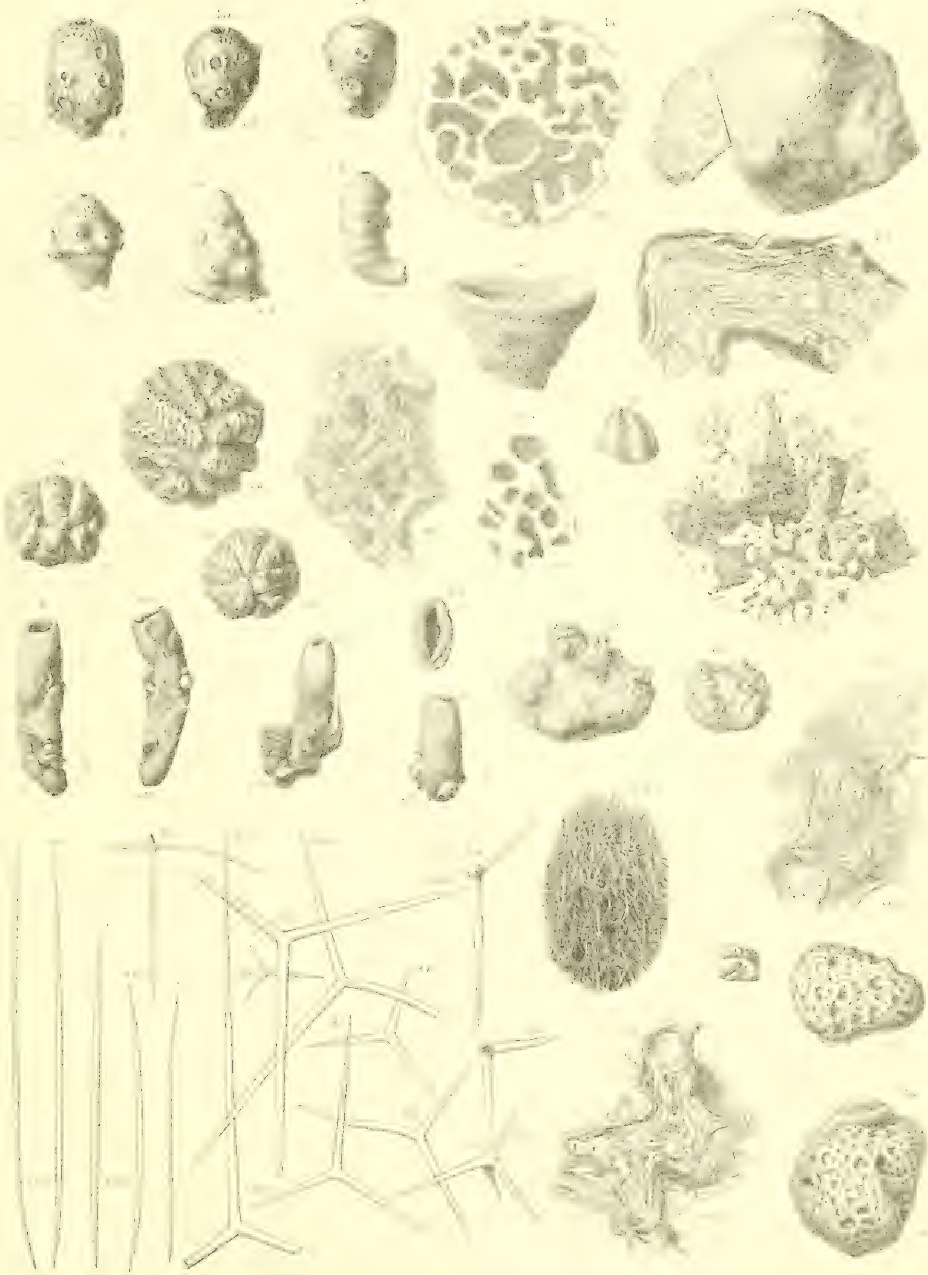
Figs. 8 *e*—8 *i*.—Five simple acerate spicules. Enlarged 200 diameters.

Figs. 8 *k*—8 *q*.—Three-rayed spicules of various dimensions. All enlarged 200 diameters. In many the rays are only in part preserved.

Fig. 8 *r*.—A sagittate four-rayed spicule, similarly enlarged.

Figs. 8 *s*—8 *u*.—Four-rayed spicules, mostly imperfect. Similarly enlarged.

Fig. 8 *x*.—A portion of the outer surface of the wall, showing the disposition of the simple rod-like spicules and traces of circular canal apertures. Enlarged 60 diameters.



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JURASSIC SPONGES